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ASTM BULLETIN

OCTOBER 1954

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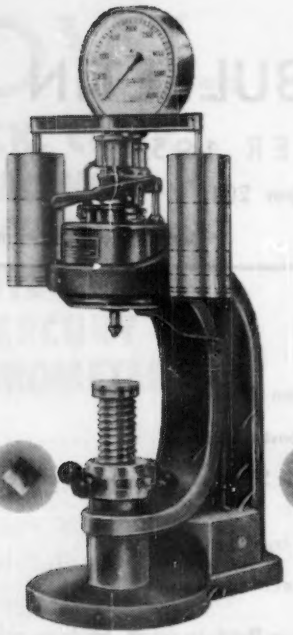

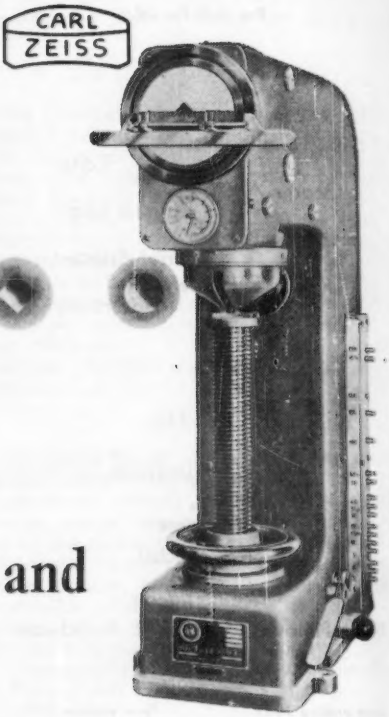

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ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering, and Standardization of Specifications and Methods of Testing"

Number 201 October 1954

A Preview of Society Publications 1954–1955

Publishing Program Continues to Expand as Research, Standardization, and Testing Activities Increase

THE numerous publications described below are evidence of the continuing expansion of the Society's publication schedule. In addition to the regular publications—Supplements to the Book of Standards, *Proceedings*, Index to Book of Standards, the Year Book, and special compilations of ASTM standards—a great many timely and interesting symposiums and special publications will be available within the next few months.

Regular Publications

Book of Standards Supplements—Index to Standards—Proceedings—Year Book

1954 Proceedings

The 1954 *Proceedings*, to be issued in February, will be around 1500 pages in size and will contain technical papers and discussion presented at the 1954 Annual Meeting. The discussions comprise a most significant feature. The papers and their discussions presented at the Annual Meeting as part of special symposiums will appear separately in special technical publications. The *Proceedings* also contains all reports with appendices submitted by the various committees during the current year. Both the Marburg and Gillett Lectures appear in the *Proceedings* although they are also issued as separate reprints.

1954 Supplements to Book of ASTM Standards

The 1954 Supplements to the 1952 Book of Standards are being issued in seven parts in heavy paper covers. They will include all new and revised standards and tentatives adopted or accepted at the Fifty-seventh Annual Meeting or by the Administrative Committee on Standards. Parts 1, 2, 4, 5, and 7 will appear in November, Part 3 in December, and Part 6 in January.

1954 Index to ASTM Standards

As the number of standards becomes larger, this Index increases in value. It provides the latest reference to publications in which the various specifications and test methods appear. This volume is particularly useful in years when supplements to the Book of Standards are issued because of the increased number of books indexed. Publication of the 1954 edition is scheduled for February.

1954 Year Book

The Year Book, which became available early in October, contains a list of the complete membership and official company-member representatives (name, title, address, company, etc.), a list of geographical distribution of members and personnel of all ASTM committees, as well as other useful information about the Society. It is furnished to members free of charge on request.

Special Technical Publications

Symposiums—Marburg and Gillett Lectures—Effect of Temperature Report—Metal Cleaning Pibliography—Fatigue References—Viscosity Index Tables

The following symposiums, featured as part of the 1954 Annual Meeting, will be published separately with discussions. Summaries of the various papers comprising these symposiums appeared in the May issue of the ASTM BULLETIN.

1954 Annual Meeting Symposiums:

Coal Sampling
Temperature Stability of Electrical Insulating Materials
Odor
Permeability of Soils
Effect of Cyclic Heating and Stressing of Metals at Elevated Temperatures
Methods of Testing Building Constructions

Symposium on Coal Sampling (STP 162)

Sponsored by Committee D-5 on Coal and Coke, this is a most significant presentation of coal sampling papers. The authors represent both companies utilizing coal and organizations studying the statistical problems of coal sampling here and abroad.

The first paper, "The Development of a Theoretical Basis of Coal Sampling," presents thoroughly the development of the theoretical basis of coal sampling published in the literature over the past fifty years.

"Some Recent British Work on Coal Sampling" describes some theoretical and experimental work carried out during the last two years.

The author of "Tests on the Binomial Sampling Theory" supports the theory that coal has binomial character by considering it to be a two-component system of carbonaceous and noncarbonaceous matter. He develops the thesis that the binomial variance can be

predicted within certain limits from a limited number of samples, and that the variance of small increments, however large, is also predictable within certain limits barring bias caused by systematic exclusion of certain sizes.

In the paper "A Test on a Slotted Revolving Cylinder Coal Sampler" there is presented in some detail both the test procedure and results for the purpose of assessing the procedure.

A program for testing the accuracy of an established mechanical coal sampling procedure is covered in "Tests of Accuracy of a Mechanical Coal Sampler."

"Test of the Geary-Jennings Sampler at Cabin Creek" presents the results of a thorough test of all phases of the mechanical sampling system at the Cabin Creek Plant of the American Gas and Electric Service Corp.

Experimental data on the phase of the problem which embraces the variances associated with the reduction and analysis of the gross sample of coal after it has been collected are dealt with in "The Variances of Reduction and Analysis."

In the last paper, "Multi-Lot Sampling, the Accuracies in Sampling of Large Coal Shipments by Application of the Variance Concept," a system is described for applying the variance concept of coal sampling to routine sampling work.

Not only those concerned with the coal industry but those using bulk sampling will be interested in this symposium, especially in the statistical methods which would reduce labor and expense and improve accuracy.

This symposium should be available late in November or early December.

Symposium on Temperature Stability of Electrical Insulating Materials (STP 161)

For many years insulating materials have been divided into several temperature classes based to a large extent on a broad definition of their composition, that is, organic, inorganic, combinations of organic and inorganic, etc. Service experience over many years has served generally to confirm the classifications and to establish the suggested temperature limits for each class. However, during the years the classes and the temperatures associated with them have in some cases become too restrictive in view of the rapid development of new insulating materials. It has therefore become increasingly apparent that insulating technology can no longer wait for the confirmation of heat stability by service experience alone. Test methods must be developed and accepted which can also serve as guides in this respect. The first ASTM Symposium on Temperature Stability of Electrical Insulating Materials is an important part of such effort. Work is in progress to develop generally accepted standards for determining the thermal stability of insulating materials.

A more extensive article describing the various papers included in this symposium appeared in the September issue of the BULLETIN.

• **This 136-page publication is now available.** Copies can be obtained from ASTM Headquarters, 1916 Race St., Philadelphia, Pa. Price: $2.75; to members, $2.

Symposium on Odor (STP 164)

The odorous properties of materials, pleasant, unpleasant, or with mixed cultural associations, stemming from the materials directly or so distantly removed from them that the odor source is obscure, have been increasingly recognized as fruitful subjects for study. Nomenclature, measurement, and control in this field all present somewhat unique problems. Because the perceptive mechanism of odor is perhaps the least perfectly understood among man's senses, nomenclature must have a subjective basis and may be a source of confusion in communication if it is not clarified. Problems in measurement are complicated by the facts that (*a*) many odorants are easily perceived in concentrations that are undetectable by direct physical or chemical methods, and (*b*) the measurement of an odor cannot be related to a perceptual mechanism (as can vision or sound, for example) and hence must be subjective, or organoleptic. In the applications field, there have been a number of interesting approaches to problems of odor control or modification, some of which have reached active commercial practice.

In an effort to provide a critical summary of the present status of odor technology, Committee D-22 on Methods of Atmospheric Sampling and Analysis sponsored this Symposium on Odor. It is intended that the researches and reviews included in the symposium volume will summarize and illustrate the "state of the art" in the industrial odor field, covering the aspects of nomenclature, measurement, and control. Nomenclature is discussed in the initial paper dealing exclusively with this subject. Measurements are described in three papers devoted to temperature-rise method for combustible odorants, organoleptic appraisals of complex systems, and a test room for odor evaluations by a panel in a static system. Control problems are taken up in a paper dealing with outdoor odor pollution and a summary review on control methods.

This symposium will be available in November.

Symposium on Permeability of Soils (STP 163)

Flow of water through soils has been much tested and studied theoretically. Despite the apparent simplicity of permeability tests, the rate of flow is affected by so many variables that divergent results are often obtained for apparently duplicate samples and there are often large differences between laboratory and field measurements. This symposium, sponsored by Committee D-18 on Soils for Engineering Purposes, includes discussions of terminology, surface chemistry, structure, field and laboratory test methods and results, and a selected bibliography which should be helpful in developing standard test procedures.

The paper on "Principles of Permeability Testing of Soils" outlines certain fundamental principles to be applied in permeability testing.

In "The Water Movement Through Porous Hydrophilic Systems Under Capillary, Electric, and Thermal Potentials," the author points out that in all types of moisture transmission through fine-grain, cohesive soils, the interaction of the internal soil surface with the water phase is of definite and often decisive importance and that there is no valid cause for continued neglect by the soil engineer of the available information.

The development of a test method to determine the permeability of sands is described in "Permeability Test for Sands," and the method, which is a modification of Barber's falling-head permeability test, is simple to use and gives reproducible results.

"Low-Head Permeameter for Granular Materials" contains a description of the apparatus and method of test for measuring the permeability of granular materials using a small hydraulic gradient.

The major factors influencing the permeability of fine-grain soils are soil composition, permeant characteristics, void ratio, structure, and degree of saturation, all outlined in "The Permeability of Compacted Fine-Grained Soils." In this paper data are presented

to indicate the magnitude of the influence of each of these variables.

The paper, "The Permeability and Settlement of Laboratory Specimens of Sand and Sand-Gravel Mixtures," describes the procedure and presents the results of laboratory permeability- settlement tests on sand and sand-gravel mixtures.

A knowledge of the soil coefficient of hydraulic conductivity was stressed as being needed to predict rationally the proper depth and spacing of farm-drain tiles and drainage ditches in "Measurement of the Hydraulic Conductivity of Soil, in Place."

A paper entitled "Measurement of Permeabilities in Ground-Water Investigations" presents certain physical conditions which must be considered in the measurement of permeabilities of soils and sediments.

The object of the paper on "A Method of Determining the Permeability of Granular Materials, Using Air Subjected to a Decreasing Pressure Differential" is to describe the design and operation of an apparatus for determining the coefficient of permeability of granular soils, utilizing air as the percolating fluid, under so-called falling head conditions. Also included in the symposium volume, which is expected to be available early next year, are selected references on permeability.

Symposium on Effect of Cyclic Heating and Stressing on Metals at Elevated Temperatures (STP 165)

It has long been realized that much, if not most, engineering use of metals at elevated temperature involves periodic changes in temperature or stress or both. However, the engineer has available for most metals only constant stress and temperature data for design purposes. This poses the question of how changes in stress or temperature modify the constant stress and temperature behavior of metals and thus the designs based on such behaviors.

It was decided by the Gas Turbine and Basic Research Panels of the Joint ASTM-ASME Committee on the Effect of Temperature on the Properties of Metals to hold a Symposium on the Effect of Cyclic Heating and Stressing on Metals at Elevated Temperatures which is intended to cover those situations involving relatively slow changes in stress or temperature or both. In practice many such changes are aperiodic, and much of the experimental work covering this symposium uses periodic variations. It is hoped that certain general considerations may, however, be deduced from the experimental results herein.

As far as cyclic variation of stress is concerned, extremely rapid stress variation is commonly considered under the general subject of fatigue. It was decided not to encompass this subject in order to limit the scope of the symposium. The dividing line between what might be called a periodic variation of stress and a rapid variation of stress leading to a fatigue failure is obviously hard to define. However, it is apparent that both differences in experimental technique and in application to design problems have led to such a division's being easily made.

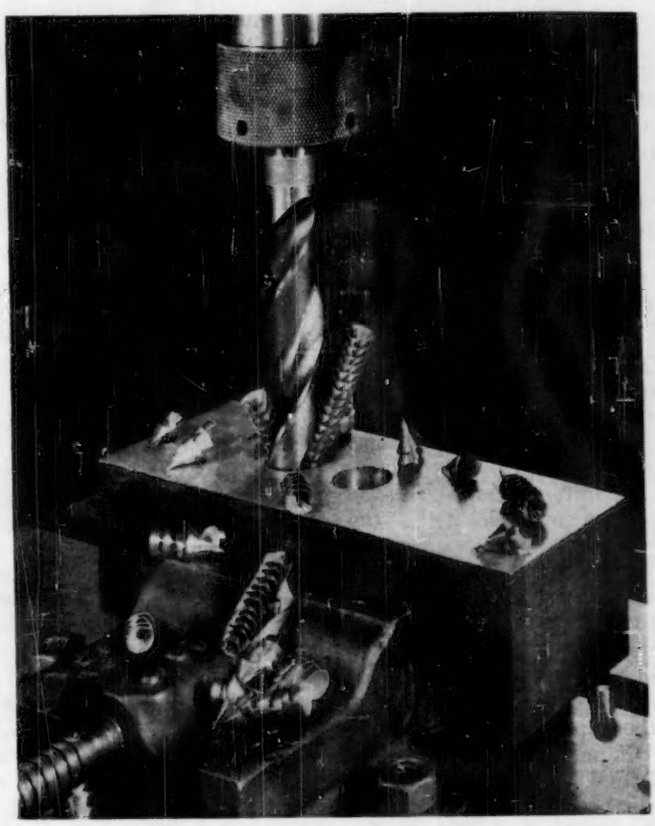
Two of the eight papers cover various theoretical aspects including creep under intermittent load and cyclic thermal stresses due to cyclic temperature changes. Three papers discuss creep and rupture data taken under intermittent load and temperature for various wrought high-temperature alloys in bar or forging form. Included are stainless steels as well as austenitic "super alloys." Two papers present intermittent load and temperature data for a number of alloys in sheet form. Both ferrous and non-ferrous alloys are included here. The final paper deals with the effect of cyclic temperatures on the scaling behavior of heat-resisting alloys.

It is hoped that the information contained herein will be of use both to the engineer-designer, as an aid in designing for stress or temperature variation, and to the researcher, as a spur to greater efforts to obtain more exact data or design criteria.

The symposium is scheduled to appear in November.

Symposium on Methods of Testing Building Constructions (STP 166)

An ever-widening interest in the evaluation and measurement of the performance of building constructions pointed to the need for a symposium covering methods of testing building construction. It is intended that this symposium will help resolve certain conflicts; on the one hand different interest groups need evaluation methods, whereas on the other hand, each interest is confronted with conflicting problems of cost *versus* size and



Machinability Testing—Drilling of a Free-Machining Plate Steel.

Third Prize, General Photographs, Ninth ASTM Photographic Exhibit. E. P. Morgan, U. S. Steel Corp., Pittsburgh, Pa.

The machining characteristics of steels are evaluated by drilling samples and measuring the rate of drill penetration. Also the machining characteristics are indicated by the thickness and brittleness of the chips produced by drilling.

number of specimens, and laboratory *versus* field performance.

Impetus for this symposium, sponsored by Committee E-6 on Methods of Testing Building Constructions, was the apparent need for directing attention at this time to the present status of development in the field of building research and the development of methods for evaluating building construction. It is hoped that this summary of current status will suffice to stimulate research work in areas which have hitherto been neglected. To this end the symposium attempts to define in part some of the neglected areas.

The paper, "Why Test Building Constructions?" reviews the progress of building construction from ancient times up to the present. Another paper, "Structural Performance Requirements in Housing Codes," discusses performance code requirements, explaining that such requirements still need to include material specifications.

The results of tests on the transverse resistance of 6-in. brick walls are covered in the paper "Transverse Tests of Masonry Walls," and a rational approach to working stresses is suggested, based on the probability distribution of extreme-value data.

Fire tests of building constructions has been a much discussed subject and in "Fire Tests of Building Structures and Materials and Their Utilization in Building Code Requirements," the author attempts to clarify the difference between fire and flame tests prepared by those interested in materials only and those prepared by groups interested in fire protection.

A history and bibliography of "Wood Diaphragm Tests" is included in which the author traces the progress in research and test programs for the earliest recorded in 1929 by the Forest Products Laboratory, down to the current activities now under way at the same laboratory and in other centers. "Glued and Nailed Roof Trusses for House Construction," presents data in an attempt to answer the question as to whether glued trusses would give better service than lightweight nailed trusses. The subject of diaphragms is also discussed in the paper "Lateral Tests on Full-Scale Lumber- and Plywood-Sheathed Roof Diaphragms," and this paper summarizes part of an over-all objective of several organizations to develop rational design data which can be used by structural engineers in the design of buildings.

It is expected that this symposium volume will be available in December.

Marburg Lecture

The Marburg Lecture given each year at the Annual Meeting originated as a memorial to the first Secretary of the Society and was established to emphasize the importance of furthering knowledge of properties and tests of engineering materials. At the 1954 Annual Meeting, the 28th Edgar Marburg Lecture, entitled "Interpretation of Scientific and Engineering Data," was presented by Harold F. Dodge, Quality Results Engineer and Member of the Technical Staff, Bell Telephone Laboratories, Inc., New York, N. Y.

In this lecture, Mr. Dodge discusses the role played by sampling and quality control techniques, giving particular attention to the application of some of the simpler statistical methods used in the interpretation of data obtained in development, production, and inspection activities. In industry, the development and production of materials and manufactured products involves at every turn the collection, analysis, and interpretation of quantitative data. Most engineering data can advantageously be regarded as a sample to tell something about a larger whole or about the behavior of the cause system or process that gave rise to the data.

Copies of this lecture will be available in November.

Gillett Lecture

The third H. W. Gillett Memorial Lecture, "Fatigue of Aluminum," is by R. L. Templin, Assistant Director of Research and Chief Engineer of Tests, Aluminum Company of America.

The lecture is sponsored jointly by ASTM and Battelle Memorial Inst. and commemorates Horace W. Gillett, one of America's leading technologists and metallurgists and the first Director of Battelle.

Mr. Templin gives a brief description of the phenomenon of fatigue of metals and a discussion of the mechanism of fatigue failure.

The investigational work on the fatigue properties of aluminum alloys that has been going on continuously during the past 35 years has provided extensive information, but the data are not of sufficient scope to answer all fatigue problems that have occurred. A better knowledge of states of combined stress, repeated shear stresses, various stress-raiser configurations, all at both room and elevated temperatures is needed.

Although the simple smooth and notch-type laboratory fatigue specimens give useful information, results from them are not directly applicable by designers in most instances.

Much progress has been made in evaluating the fatigue properties of aluminum alloy structural components, the relative merits of different geometric configurations and fabrication procedures, but the problems in this category are legion.

Fatigue strengths of structures can be improved in many instances by use of the information from comparisons of different designs of components. This appears to be a valid conclusion irrespective of whether aluminum or other metals are used.

Copies of this lecture, a reprint from the 1954 *Proceedings*, will be available in October.

Symposium on Effect of Temperature on the Brittle Behavior of Metals with Particular Reference to Low Temperatures (STP 158)

Despite the existence of a large accumulation of data, technical papers, and reports on low-temperature properties and behavior of metallic materials, sudden, unexpected, and frequently disastrous failures continue to occur in engineering structures and expensive equipment. Very little of the wealth of available information has been fully evaluated and published in the commonly used handbooks. Furthermore, it is apparent that there is a lack of general comprehension and application of the knowledge which has been reported by investigators concerning important metallurgical and mechanical variables and their influence on low-temperature ductility and the mechanism of fracture.

Consequently, the Low Temperature Panel of the ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals sponsored this symposium in 1953 to bring together and summarize the state of knowledge of the subject, up to the present, in an effort to make designers and materials engineers more fully cognizant of the joint role played by metallurgical and mechanical factors in their influence on the behavior of metals at low temperatures, and particularly of the variable response to variations in stress systems, strain rates, and size effects.

Some idea of the extent of the coverage may be had from the fact that twenty-seven papers were presented during the five sessions of the symposium. They covered the following broad fields (1) the evaluation of brittle failures in ships and engineering structures, (2) criteria of metal behavior for design engineers, (3) metallurgical and

mechanical factors, (4) significance and reliability of notch toughness tests, and (5) certain aspects of current research, including new data on titanium, quenched-and-tempered steels at high strength levels, and several types of cast irons.

• This 480-page publication is now available. Copies can be obtained from ASTM Headquarters, 1916 Race St., Philadelphia, Pa. Price: $7.50; to members, $5.65.

Symposium on Radioactivity—An Introduction (Radioisotopes—Laboratories—Personnel—Radiation Management Problems—ASTM Work) (STP 159)

Committee E-10 on Radioactive Isotopes was formed to promote the knowledge of the use of radioactive isotopes in materials testing, to aid and advise other technical committees of the Society interested in their use, and to perform other related appropriate functions in this field. The committee considered that its main objective was to bring to the attention of ASTM members the potential usefulness of radioactive techniques, and that a Symposium on Radioactivity would give the potentialities of radioactivity testing and measurement.

This symposium is an effort to develop information for those who are in a position to put it to practical use. Through it, the reader will have a clearer picture of what the radioactivity tool or technique consists and where it can be used.

It was not originally planned to publish this 1953 symposium, but the papers and discussion were so enthusiastically received that the authors were asked to submit their manuscripts for publication. The papers comprising this symposium cover properties and uses of radioisotopes, application of radioactive measurements to ASTM work, design of radioisotope laboratories, training personnel in radioisotope techniques, instrumentation, and management problems resulting from radioisotope utilization by industry.

• This 52 page publication is now available. Copies can be obtained from ASTM Headquarters, 1916 Race St., Philadelphia, Pa. Price $1.75; to members $1.35.

Symposium on Color

The Symposium on Color of Transparent, Translucent Products held at the 1954 Spring Meeting of the Society last February is being published in both this and the December issue of the BULLETIN and will be available as a separate reprint.

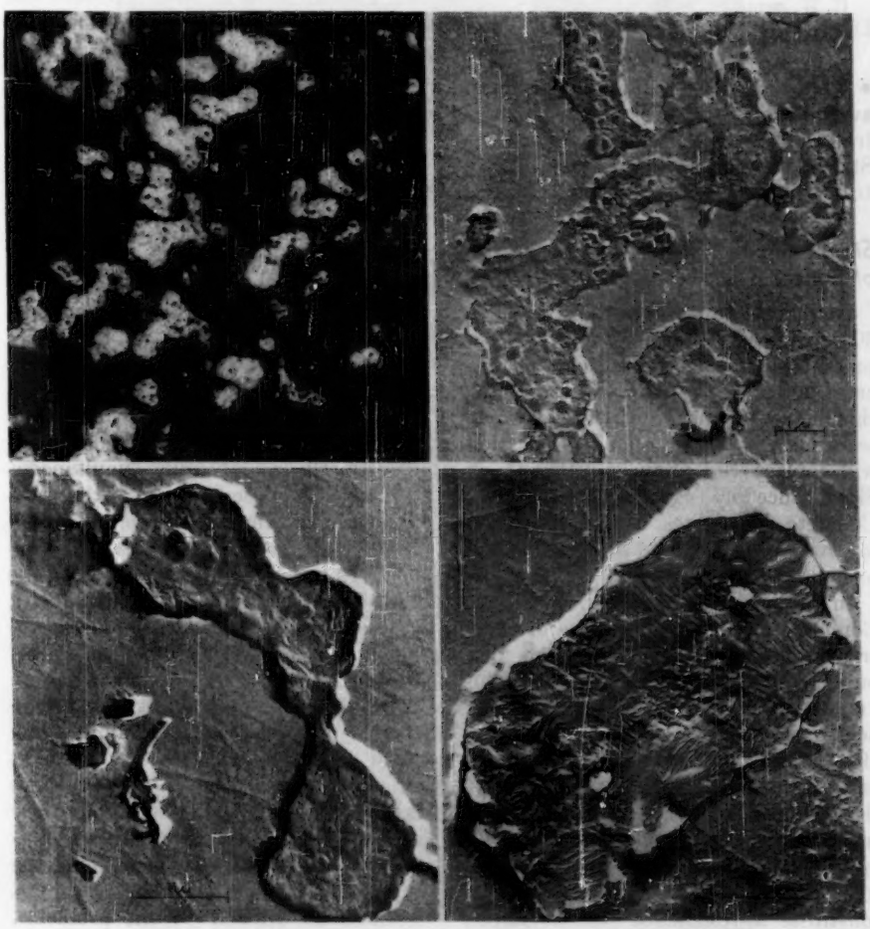
In the seven papers, the first four of which start on page 31 of this issue, the authors review color measurement and control techniques in industries in which color of transparent and translucent materials is important. They point out the unevenness in the development of methods among industries and the inadequacies, limitations, and unsolved problems that occur. The dollar value of these problems is emphasized, underlining the need for adequate financing of research programs and proof that these costs are justified. The naval stores, plastics, brewing, paints, foods, color styling, oils, and dairy products industries are represented in these papers.

Two advantages that can be derived from a series of papers covering such a wide scope are appreciation of the diverse uses of color measurement and the similarities in the problems facing the various industries.

Symposium on Diesel Fuels (STP 167)

This symposium was developed under the auspices of Technical Committee F of Committee D-2 on Petroleum Products and Lubricants for the purpose of contributing to a more complete understanding of the problems that relate to better production, selection, and utilization of diesel fuels.

The eight papers listed below cover the diesel fuel supply and demand outlook, the various problems associated with the procurement and use of diesel fuels, as well as a review of the diesel fuel specification requirements which



Electron Micrographs of Microstructure of Fine Nickel Particles, Polished and Etched Cross-Sections (Reduced for publication)

Honorable mention, Electron Micrographs—Non-Ferrous, Ninth ASTM Photographic Exhibit. E. W. G. Cortney, Chemical Construction Corp.; L. Delisle Pellier, F. G. Rowe, and E. J. Thomas, American Cyanamid Co., Stamford, Conn.

Upper left, photomicrograph. Light etching revealed cored structure of particles (3000 ×). Cores may be nuclei from which the particles grew and agglomerated. *Upper right:* electron micrograph, shadow-cast replica (20,000 ×). *Lower left and right:* electron micrographs, shadow-cast replica (40,000 ×). Deeper etching brings out finer structure of cores. Etch figures also indicate various crystallographic orientations within particles.

have been investigated by Technical Committee F.

The Availability and Demand Outlook, Distribution, and Principal Properties of Domestic Diesel Fuels, by C. M. Larson

Diesel Fuel Specifications Requirements, by C. C. Ward

The Increasing Use of Furnace Oils for Diesel Fuel, by Harold V. Messick

Distribution and Storage Problems with Diesel Fuels, by C. C. Moore and W. P. Lakin

Survey of Diesel Fuel Oils Available at Roadside Filling Stations, by William A. Howe

Technical Problems Associated with Diesel Fuels in Contractors' Equipment, by J. W. Vollentine

Technical Problems Associated with Diesel Fuels in Interstate Coach Operation, by W. A. Duvall

Technical Problems Associated with Diesel Fuels in Railroad Operations, by R. W. Seniff

Diesel Fuels in Marine Operations, by C. E. Habermann

• **This 56-page publication is now available.** Copies can be obtained from ASTM Headquarters, 1916 Race St., Philadelphia, Pa. Price: $1.50; to members, $1.15.

Significance of Tests and Properties of Concrete and Concrete Aggregates

An extensive volume of more than 30 papers will constitute a review of the present status of the testing of concrete and concrete aggregates and the significance of the properties for which tests may be made. This publication will replace the previous "Report on Significance of Tests of Concrete and Concrete Aggregates," the first edition of which was published in 1935 and the second in 1943.

In the course of the deliberations in Committee C-9 on Concrete and Concrete aggregates, the sponsor of this publication, it was decided that the knowledge and the problems in this field had increased so greatly since the 1943 edition was issued that the scope and arrangements for contributing authors should be revised along with the revisions in subject matter. Accordingly, the new edition will not be limited to significance of tests as such, but will constitute a résumé of present information on the significance of the properties of concrete and concrete aggregates and the tests by which they are studied and determined. In essence, this is visualized by the committee as a change from the confining limits of what we do in tests that are made, tests that should be made, research and development that should be carried out to establish tests for interpretation of properties, and the evaluation and significance of all these factors in terms of the uses being made of concrete and concrete aggregates.

More detailed information will be given in future issues of the BULLETIN as further progress is made on this report which is scheduled to appear in the spring of next year.

Piles Subjected to Lateral Thrust (STP 154 A)

Two papers were presented at the Annual Meeting which are so closely related to the Symposium on Lateral Load Tests on Piles (STP 154) that they are being issued as a supplement to that 1953 symposium. The general title of these two papers is "Piles Subjected to Lateral Thrust." Part I on measurement of earth pressure and deflection along the embedded portion of a 40-ft steel pile is by H. G. Mason and J. A. Bishop. Part II by L. A. Palmer and P. P. Brown is on analysis of pressure deflection, moment, and shear by the method of difference equations.

In Part I the details of a test installation in which a full-scale pile was embedded in an earth fill and subjected to lateral loads are outlined. The authors describe the instrumentation, including means of measuring pressures and deflections at intervals along the entire pile length. An example of the pressures and deflections obtained is presented and a comparison is made between measured and theoretical values. Two methods of solving simultaneous difference equations such as those involved in the analysis of the problem of computing lateral earth pressures, deflections, shears, and moments along the embedded length of pile are introduced.

Part II utilizes the earth-pressure and pile-deflection data contained in Part I to show the effect of different variables, particularly the parameters, k and n, on the magnitude of the maximum bending moment in the pile and the depth at which it occurs. This part also outlines applications of the data and their analyses in engineering design and presents a concise system for defining the expressions used in the method of differences as applied to the problems. The data presented in Part I are used in Part II for computing moments and shears along the embedded pile length and to evaluate the separate variables, stiffness factor of pile, width of pile pushed against soil, the height of thrust above the ground line and the parameters, k and n, with respect to their effects on earth pressures, pile deflections, and shears and moments at all depths of pile embedment.

These two papers along with discussion will be published as a separate pamphlet sometime this fall.

Report on the Elevated-Temperature Properties of Selected Super-Strength Alloys (STP 160)

This is the third in a current series of reports prepared under the auspices of the Data and Publications Panel of the ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals. The first report of this series covered a number of the commercially produced stainless steels (*STP 124*), and the second report covered the chromium-molybdenum steels (*STP 151*).

This report is primarily a graphic summary of the elevated-temperature strength data for 13 selected super-strength alloys. Included are summary curves for tensile strength; 0.2 per cent offset yield strength; per cent elongation and reduction of area; when available, stresses for rupture in 100, 1000, 10,000, and 100,000 hr; and stresses for creep rates of 0.0001 and 0.00001 per cent per hr (1 per cent in 10,000 and 100,000 hr). Also included are brief descriptions of each alloy giving chemical composition and recommended heat treatments and processing. The original data sheets containing the primary data from which the summary curves were prepared are given. These data sheets also contain the chemical composition, processing data, heat treatment, and other pertinent information for the specific heats for which data are given. The Appendix contains some very short-time-rupture data for several of the alloys, and a compilation of chemical compositions for approximately 100 super-strength alloys.

Since it was not possible to include all of the so-called "superalloys" in this survey, a choice had to be made of the alloys for which data would be solicited. The alloys selected for this solicitation were chosen by the Data and Publications Panel and included the following: 19-9DL; 16-25-6; Discaloy 24; A-286; N-155; S-590; S-816; Haynes Alloy No. 25; Refractaloy 26; Inconel "X"; M-252; Haynes Alloy No. 21; and Haynes Alloy No. 31.

Reports are scheduled for the future on copper-base alloys and on the relaxation properties of metals at elevated temperatures.

• **This 220-page publication is now available.** Copies can be obtained from ASTM Headquarters, 1916 Race

St., Philadelphia, Pa. Price: $4.75; to members $3.50.

1954 Supplement to the Metal Cleaning Bibliographical Abstracts (STP 90 C)

This 1953 Supplement, prepared by Jay C. Harris of Monsanto Chemical Co., is intended to bring up to date the coverage by this bibliography of the published data on metal cleaning. The new references total 227.

The 1954 book supplements the 1953 edition (*STP 90 B*) which was a combined publication of all references from 1842 to 1951. Therefore this supplement (*STP 90 C*) with the 1953 combined bibliography contains all available references for the years 1842–1953.

As previously the references, numbered consecutively, are arranged by year and secondarily by author (or by the journal in which the article appeared if anonymous). In order to facilitate reference to the abstracts they have been thoroughly indexed by subject, author, specification, and patent.

Wherever possible the original articles have been abstracted. In a field of such size, to read and abstract each original reference is virtually impossible of accomplishment, so that many articles which appear herein are reabstracts from journals such as *Chemical Abstracts* or *Journal of the Institute of Metals*.

This supplement will be available early in November.

1953 References on Fatigue (STP 9-E)

Following the plan used in previous annual lists (1950–1952) of fatigue references the latest list of references to articles published in 1953 on the subject of fatigue is now available. Brief abstracts of the articles have been included when these were readily available. This list is not exhaustive but is sufficiently extensive to be of interest to those concerned with this field. References are generally so arranged that sheets can be cut apart for filing according to any desired plan. This is a Committee E-9 on Fatigue sponsored project.

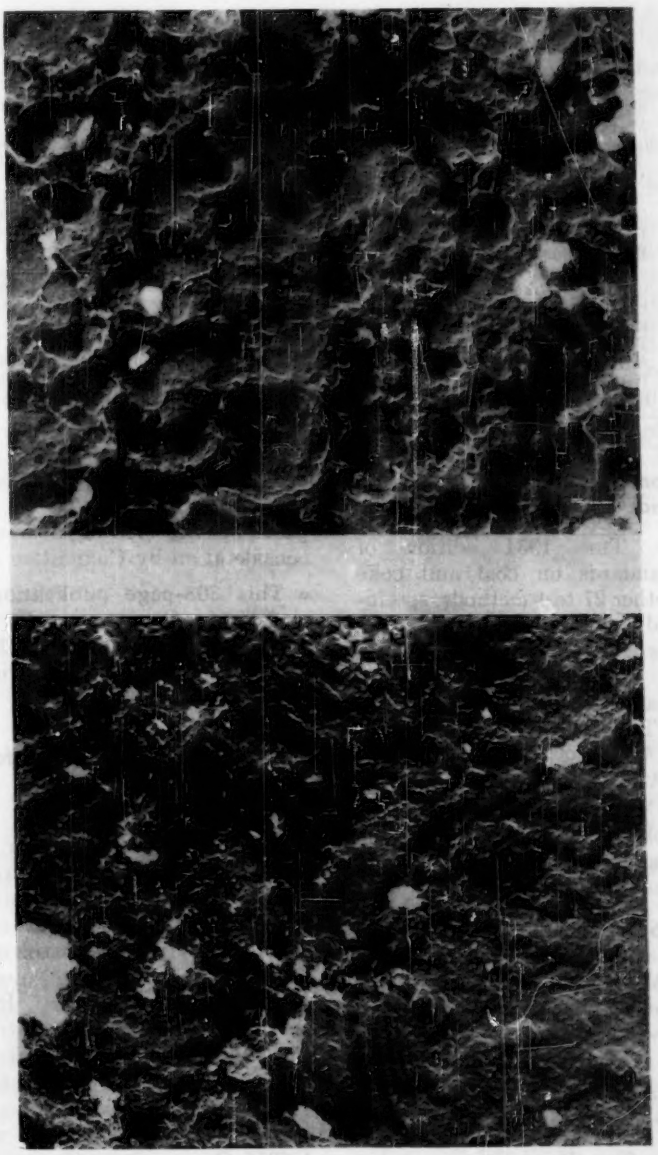
• **This publication is now available.** Copies can be obtained from ASTM Headquarters, 1916 Race St., Philadelphia, Pa. Price: $1.85.

Viscosity Index Tables—STP 168

THIS publication provides convenient reference tables for obtaining calculated Viscosity Index values obtained from basic kinematic values (in centistokes) given in ASTM Standard D 567 and ASTM Viscosity Tables STP 43-A. Kinematic viscosity values at 100 F are listed for increments of 1 V.I. The frequency of entry into the tables with kinematic viscosity at 210 F is as follows:

Viscosity Range, cs at 210 F	Frequency of Entry, cs	Viscosity Indices Listed
2.000 to 2.498	0.002	0 to 150
2.500 to 4.995	0.005	0 to 150
5.00 to 9.99	0.01	0 to 150
10.00 to 24.98	0.02	0 to 150
25.00 to 44.95	0.05	0 to 140
45.00 to 49.95	0.05	0 to 130
50.0 to 75.0	0.1	0 to 130

Approximately 850 pages, cloth cover, 7 by 10 in., scheduled to appear in December.



Electron Micrograph of Worn Tire Treads Made of Reinforcing and Nonreinforcing Pigments (× 10,000). (Reduced for publication).

Third prize, Electron Micrographs, General, Ninth ASTM Photographic Exhibit. E. H. Rowe, B. F. Goodrich Research Center, Brecksville, Ohio.

Top: a road-worn tire tread compounded with a nonreinforcing pigment, showing deep gouges where particles of tread have been removed by the road. *Bottom:* a similarly worn tire tread compounded with an EPC carbon black, showing a smoother surface, indicating less wear. A Faxfilm-silica replica technique was used with chromium shadowing of the Faxfilm.

1954–1955 Publications

Special Compilations of Standards

The tabulation given below of special compilations of standards should be viewed as approximate only. There are so many factors entering into publication of these books that it is not possible to give any exact estimate of size or the date on which they will become available. The size is affected by committee recommendations which may still be submitted to the Administrative Committee on Standards and the date of issue is governed somewhat by editorial considerations and also their relation to the appearance of the Supplements to the Book of Standards. Several of the compilations listed as being available in September were described in the September issue of the BULLETIN, and more additional information with respect to several others whose appearance is imminent is given elsewhere in this BULLETIN.

Sponsoring Committee	Title	Approximate Number of Pages	Approximate Publication Date
A-1	Steel Piping Materials	376	January
B-1	Metallic Electrical Conductors	272	October
B-5	Copper and Copper Alloys	584	September
C-1	Cement	266	April
C-9, D-4	Mineral Aggregates, Concrete, and Nonbituminous Highway Materials	346	December
C-14	Glass	210	April
D-2	Petroleum Products and Lubricants	918	November
D-4, D-8	Bituminous Constructional Materials for Highway Construction, Waterproofing and Roofing	438	September
D-5	Coal and Coke	166	September
D-9	Electrical Insulating Materials	642	January
D-11	Rubber and Rubber-Like Materials	730	January
D-13	Textiles	720	October
D-14	Adhesives	230	September
D-19	Water Manual	422	September
	Building Code	950	February

Compilation of Standards on Coal and Coke

THE 1954 edition of ASTM standards on coal and coke brings together 27 test methods, specifications, and definitions of terms in their latest approved form together with Tentative Revisions of Laboratory Sampling and Analysis of Coal and Coke, and Test for Free-Swelling Index of Coal. All these have been developed by ASTM Committee D-5 on Coal and Coke.

Also published as appendices, as information and for comment, are eight proposed methods of test.

• **This 166-page compilation is now available.** Copies can be obtained from ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa. Price: $2.25; to members, $1.70.

Compilation of Standards on Adhesives

THE Third Edition of the compilation of Standards on Adhesives, sponsored by Committee D-14 on Adhesives, brings together all ASTM specifications and methods of test pertaining to adhesives.

Also included are methods of testing materials allied to adhesives which have been prepared by seven other ASTM committees and, in addition, four proposed or suggested methods now under consideration by Committee D-14.

• **This 208-page publication is now available.** Copies can be obtained from ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa. Price: $1.75; to members, $1.35.

ASTM Copper Strip Corrosion Standards for Petroleum

These ASTM Copper Corrosion Standards are available for use with Method D 130 in the detection of the corrosiveness to copper of automotive gasoline, aircraft engine fuels, farm tractor fuel, cleaners (Stoddard), solvent, Diesel fuel, fuel oil (distillate), and certain other petroleum products. In Method D 130 a polished copper strip is immersed in a sample of the material being tested at a definite temperature time. The copper strip is then washed and compared and evaluated with the ASTM Copper Strip Corrosion Standards.

Studies have been under way for several years to provide adequate reference standards, and it is believed this set of visual standards will be of widespread interest and use. They have been prepared by the Central Scientific Co. in cooperation with a leading lithographer and are distributed from ASTM Headquarters.

The actual corrosion comparison standards approved by the committee comprise thirteen various colored strips produced by a photolithographic process on aluminum and arranged according to increasing severity of attack. Because of the nature of these standards, it is not possible at this stage to state how long the colors will remain permanent. Every effort has been made to insure reasonable longevity. Each set of standards is available in a plastic case which includes instructions for use, together with a copy of the current Method D 130.

• **These standards are now available.** They can be obtained from ASTM Headquarters at a price of $25.

Miller Heger Report Again Available

OUR stock of the Report on the Strength of Wrought Steels at Elevated Temperatures prepared by R. F. Miller and J. J. Heger, under the auspices of the ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals, has been depleted for the past several months. We are happy to announce that we were able to have additional copies of these 109 pages ($8\frac{1}{2}$ by 11-in. page size) of tables and graphs reproduced.

Copies may be secured through ASTM Headquarters. Price: $3; to members, $2.25.

OFFERS OF PAPERS FOR 1955

THE Administrative Committee on Papers and Publications will meet in early February to consider the papers to be published by the Society in 1955 and to develop the program for the Annual Meetings to be held in Atlantic City, N. J., June 26 to July 1.

All those who wish to offer papers for presentation at the meeting and publication by the Society should send these offers to Headquarters *not later than January 15, 1955.* All offers should be accompanied by a summary which will make clear the intended scope of the paper and will indicate features of the work that will, in the author's opinion, justify its publication and inclusion in the Annual Meeting program.

Suitable blanks for use in transmitting this information will be sent promptly upon request to Headquarters.

Department of Commerce Clarifies Standardization and Simplification Activities

New Agency—BDSA—Consolidates Liaison Programs

THE United States Department of Commerce which last fall established a Business and Defense Service Administration has clarified the activities the new administration will carry out in standardization and simplification work. This new agency (*a*) continues the residual defense and mobilization functions of the former National Production Authority, as authorized by law, (*b*) consolidates five current departmental offices, (*c*) establishes 25 industry divisions, headed in rotation by business experts lent by Government and private industry, and (*d*) provides a focal point for effective cooperation between Government and business in promoting economic stability and growth.

The offices transferred to the BDSA are: the Office of Technical Services, the Office of Distribution, the Field Service, staff functions of the Industry Evaluation Board, and the Office of Industry and Commerce, including its Trade Association, Commodities Standards, and Area Development Divisions.

The BDSA is primarily designed to serve business, to promote the expansion of employment opportunities, and in diverse ways to stimulate economic growth and stability, thus benefiting managers, workers, consumers, and the general public.

It will be a listening post and sounding board for bringing business information and business opinion on vital matters relating to Government and industry, including reports on business conditions, to the direct attention of the Commerce Department for appropriate action. One phase of all this is greater cooperation between the Department and industry groups and trade associations.

In carrying out its national emergency responsibilities, the new agency will preserve the nucleus of an organization which can rapidly be expanded in the interest of national security. It will also foster an orderly transition from emergency mobilization efforts to the operation of a free enterprise system.

There are three staff offices—the Office of Technical Services, Office of Small Business, and Office of Distribution, and 25 industry divisions. The Office of Technical Services, which is a clearing house for Government technological data of interest to business, will also assist industry in voluntary product standardization and in regional and local area development problems. It is comprised of the Area Development, Commodity Standards, and Trade Association Divisions.

Lending assistance in the 25 industry divisions are a number of ASTM members and committee members who are experts in their various fields. These divisions broadly cover defense production activities, mobilization preparedness activities, and business service activities.

Currently Charles F. Honeywell is Administrator of BDSA, and H. B. McCoy, a career official of the Department, Deputy Administrator.

The Acting Director of the Office of Technical Service is John C. Green; E. W. Ely is Chief of the Commodity Standards Division; and C. J. Judkins is Chief of the Trade Associations Division. Department Order No. 155, which covers the policy on Standardization and Simplification Activities, follows:

UNITED STATES OF AMERICA
DEPARTMENT OF COMMERCE

Department Order No. 155—Effective July 9, 1954

Subject: Policy Governing Standardization and Simplification Activities of the Department of Commerce

Section 1. Purpose:

The purpose of this order is to state the policy governing the standardization and simplification activities of the Department of Commerce.

Section 2. Legal Basis:

.01 The duties and responsibilities of the Secretary of Commerce in the fields of standardization and simplification are as stated in Sec. 601 of Reorganization Plan 3 of 1946, which provides in pertinent part as follows:

> " * * * (*) to assist, coordinate, and cooperate with groups of consumers, distributors or producers, technical organizations, and other persons, in the voluntary establishment, maintenance, recording, publishing, and promoting of commercial standards as a nationally and internationally recognized basis for testing, grading, labeling, marketing, guaranteeing, or accepting staple, manufactured commodities moving in daily domestic and foreign trade;
>
> "(*) * * * to assist, coordinate, and cooperate with individual and groups of producers, distributors, and users in establishing, recording, publishing, and promoting a Nationwide program for the elimination of avoidable waste through the formulation of simplified trade practice recommendations which identify and list the sizes, types, dimensions, and varieties of products that are in national demand in the country * * *."

.02 The execution of these duties and responsibilities is hereby delegated to the Administrator, Business and Defense Services Administration, with authority to redelegate and to provide for the successive redelegation of the responsibility assigned herein.

Section 3. Departmental Policy:

.01 In performing its functions in the fields of standardization and simplification the Department and personnel assigned to these activities are to be guided by the following policies and principles:

1. The Department recognizes its obligation to supply services to the public in accordance with its statutory mandate;
2. The Department also recognizes that numerous private organizations, associations and other groups have an active interest in standardization and simplification;
3. It is a basic policy of the Depart-

ment that it will avoid engaging in activities overlapping those of private enterprise;

4. It is accordingly the policy of the Department that its standardization and simplification activities should be undertaken only in discharge of its statutory obligation and where it clearly appears that it is under public obligation to undertake such activities;
5. In determining whether particular standardization and simplification projects are to be undertaken the Department will:
   (a) Refrain from soliciting such projects,
   (b) Upon application to it to undertake such projects, inform the applicant(s) of the availability of other known private facilities for the same general type of work or services,
   (c) Prior to beginning work on any such project, obtain from the applicant(s) a statement in writing that the applicant(s) desire(s) the Department to undertake such project;
6. It is the policy of the Department to cooperate with all private organizations, associations and groups in the formulation and issuance of proper voluntary standards and simplifications; and
7. All such cooperation must be on a nonexclusive and nondiscriminatory basis as between the Department on the one hand, and such private organizations, associations and groups on the other hand.

Section 4. Effect on Other Orders:

Any other orders or parts of orders the provisions of which are inconsistent or in conflict with the provisions of this order are hereby superseded or amended accordingly.

(*Signed*) SINCLAIR WEEKS
Secretary of Commerce

Special Issue of Standards Magazine

FIFTY years of progress in the electrical industry is the theme of a special issue of the *Magazine of Standards*, published in August by the American Standards Assn.

The magazine shows the vital role played by standards in the growth of the industry and commemorates the Fiftieth Anniversary of the International Electrotechnical Commission.

—JUBILEE YEAR OF IEC—

An Historical Note of International Organization's First Fifty Years

THE International Electrotechnical Commission, celebrating its Golden Jubilee in Philadelphia this year, had its beginnings, as do all great cooperative endeavors, in man's willingness to share his hard-won knowledge and achievement with others. Calendar-wise, the IEC began in St. Louis on September 15, 1904, at a meeting of the Chamber of Delegates of the International Electrical Congress. At that meeting, under the chairmanship of Professor Elihu Thomson, the Chamber adopted the report of its Committee on International Standardization which contained the recommendation:

"That steps should be taken to secure the co-operation of the technical societies of the world, by the appointment of a representative Commission to consider the question of the standardization of the nomenclature and ratings of electrical apparatus and machinery."

The subsequent carrying out of the intent of this motion resulted in a preliminary meeting being held in London in 1906, presided over by Alexander Siemens, at which 13 countries were represented through their national technical societies. It was at this meeting that the name International Electrotechnical Commission was adopted and Lord Kelvin was elected president.

In 1908 a meeting of the Council was held in London where Elihu Thomson was elected to the presidency, Lord Kelvin having died, and Charles Le Maistre of England was appointed General Secretary, a post he held until his death in 1953. It was at this meeting that the Statutes of the IEC were formally adopted to remain practically unchanged for 40 years.

By 1914 and the outbreak of World War I the IEC had issued a first list of terms covering electrical machinery and apparatus, a list of international letter symbols for quantities and signs for names of units, an international standard of resistance for copper, a list of definitions in connection with hydraulic turbines, a number of definitions and recommendations relating to rotating machines and transformers.

After the war, activity resumed for 20 years of steady growth until interrupted again in 1939 by war. One of the highlights of this fruitful era was the 1926 meeting in New York which was attended by 120 delegates from 19 countries. This meeting coincided with a meeting of Secretaries of National Standards Bodies from 10 nations which resulted in the formation of the International Standards Assn., the predecessor of ISO. Climax of this meeting was President Coolidge's reception of the delegates at the White House.

In this productive period between world conflicts came the International Electrotechnical Vocabulary of about 2000 terms in English, French, German, Italian, Spanish, and Esperanto; the naming of units such as oerstad, gauss, maxwell, gilbert, var, and weber; numerous international standards for a wide range of electrical machinery and apparatus; lists of graphical symbols, standard system voltages, and current ratings; and rules for high-voltage testing.

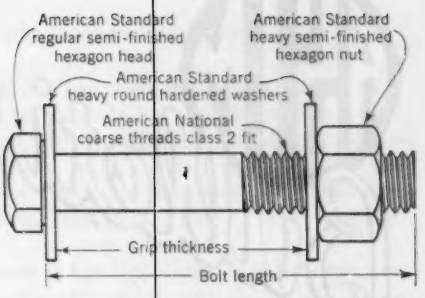
Upon resumption of its activities following World War II, the IEC, meeting in Zurich, gave approval to an agreement with the newly organized International Organization for Standardization (ISO) providing for affiliation of IEC with ISO as its Electrical Division and retaining its own administrative and technical autonomy. It was also decided to transfer the Central Office of the IEC from London to Geneva in the same building that houses the General Secretariat of ISO.

Recent growth of the IEC has been rapid. It now has 30 National Committees and 39 Technical Committees and each year large meetings have been held in various European centers. The second edition of the Vocabulary is near completion and will include 5000 terms with their definitions. Work has expanded into new areas such as electroacoustics, light current, and television.

The phenomenal expansion of electrical and electronic technology in the past 15 years augurs a second half century for IEC of even more significant accomplishment than that achieved in its first 50 years.

ED. NOTE.—The December issue of the ASTM BULLETIN will carry a news account of the IEC Jubilee meeting.

High-Strength Bolts from ASTM Specifications Used in Huge AEC Construction



ASTM high-strength bolt assembly consists of bolt, two washers, and a nut.

Courtesy Civil Engineering

$1\frac{1}{2}$ MILLION ASTM-specified bolts are pinning together the steel structural members of a new billion dollar Atomic Energy Commission plant, according to an article by H. H. Nicholson in the August, 1954, issue of *Civil Engineering*.

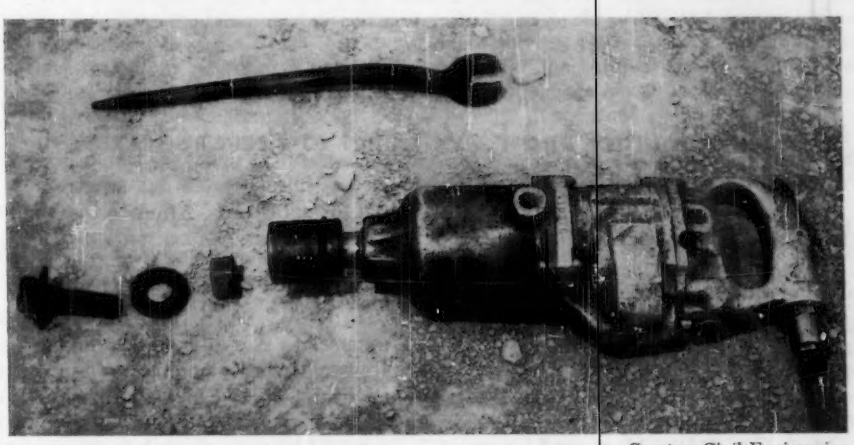
Sprawling over 3700 acres in Pike County, Ohio, midway between Chillicothe and Portsmouth, the huge plant separates uranium 235 from a chemical compound of uranium by a process of gaseous diffusion through porous barriers.

Each of the three process buildings was constructed by a different company, two using only high-strength and machine bolts, the third using both high-strength bolts and rivets. The bolt, nut, and washer material employed conformed to the requirements of ASTM Tentative Specifications for Quenched-and-Tempered Steel Bolts and Studs with Suitable Nuts and Plain Washers (A 325).

Since, according to *Civil Engineering*, high-strength bolts have been substituted for rivets only within the past seven years, this afforded an opportunity to compare the merits of riveting and bolting under similar field conditions.

Among the features found by Mr. Nicholson to favor the use of high-strength bolts, were (1) on-the-job training of iron workers can develop an expert bolting crew in 30 days, (2) with controlled operation, rejection of bolts is very low, usually under $\frac{1}{2}$ of 1 per cent and joints can be reworked without costly removal operations, and (3) a bolted connection is stronger than a riveted connection since the clamping force of high-strength bolts is greater and is constant for all grips of similar size bolts.

The author prophesies that "with continued research, refinement in design, and improvement of materials, equipment, and methods, the use of high-strength bolts as fasteners will be fairly universal in another five years."



Courtesy Civil Engineering

At left, bolt assembly together with air-operated impact wrench. *Top*, holding wrench.

Courtesy Civil Engineering

A two-man crew checks high-strength bolts. At left, holding wrench; at right, torque wrench.

ASTM Bulletin

OCTOBER 1954

NO. 201

NINETEEN-SIXTEEN
RACE STREET
PHILADELPHIA 3, PENNA.

W. J. Hamburger and F. V. Lenel to Present 1955 Lectures at Annual Meeting

Two outstanding lectures are in preparation for the 1955 Annual Meeting of the Society by Walter J. Hamburger and Fritz V. Lenel.

Marburg Lecture

Dr. Hamburger, Director of Fabric Research Laboratories in Boston, Mass., will give the Edgar Marburg Lecture on the subject of the properties of textile fibers. It was the thought of the Marburg Lecture Committee who chose Dr. Hamburger that this lecture would bring up to date the profound and significant changes that have occurred in textile technology since H. DeWitt Smith delivered his outstanding Marburg Lecture on "Textile Properties—An Engineering Approach to Their Properties and Utilization" in 1944.

Gillett Lecture

Fritz V. Lenel, Professor, Department of Metallurgical Engineering, Rensselaer Polytechnic Institute, and chairman of ASTM Committee B-9 on Metal Powders and Metal Powder Products, has been selected to present the Horace W. Gillett Memorial Lecture on the subject of metal powder compacts and products.

The Gillett Lectures, established jointly by ASTM and Battelle Memorial Inst. to honor the great American metallurgist, are confined to the field of development, testing, and application of metals.

Copies of 1951 Proceedings *Needed*

THE 1951 *Proceedings* is out of print and there continues to be a modest demand for copies of this edition. If your copy of the 1951 *Proceedings* is in reasonable condition for re-sale and you have no further use for it, the Society would like to buy it back at $5 upon its receipt at ASTM Headquarters.

Be sure a return address is on the package to enable identification, and better still, advise us that shipment is being made. If the check should be made payable to any special account or name, this should be stated clearly.

A large number of the requests for this volume are related to purchases of complete sets by individuals and libraries. Your cooperation to enable the Society to fulfill these requests will be appreciated.

ASTM MEETINGS IN '55

Committee Week

Time: January 31 to February 4
Place: Cincinnati, Ohio
Hotel: Netherland Plaza

Annual Meeting

Time: June 26 to July 1
Place: Atlantic City, N. J.
Hotel: Chalfonte-Haddon Hall

Committee Week

Committee Week has become an ASTM institution in recent years, concentrating in one week and one place a large number of committee meetings with a resulting saving to members in travel time and expense.

Special events are usually planned for this week—a symposium or session on a timely technical subject,—this year a Symposium on Basic Effects of Environment on Strength, Scaling, and Embrittlement of Metals at Elevated Temperatures, sponsored by the Joint Committee on Effect of Temperature on Properties of Metals.

Annual Meeting

In 1955 it's back to the Jersey shore for the Annual Meeting. The Society's most frequented meeting place, Atlantic City, will again be host to members and their families who combine a week of hard work in sessions and committee meetings with a seaside atmosphere and the many pleasurable features of the ASTM Annual Meetings which are growing bigger every year.

Schedule of ASTM Meetings

This gives the latest information available at ASTM Headquarters. Direct mail notices of all district and committee meetings customarily distributed by the officers of the respective groups should be the final source of information on dates and location of meetings. This schedule does not attempt to list all meetings of smaller sections and subgroups.

DATE	GROUP	PLACE
Oct. 19–22	Committee D-13 on Textile Materials	Washington, D. C. (Sheraton Park)
Oct. 25–26	Committee B-1 on Wires for Electrical Conductors	Washington, D. C. (Sheraton Park)
Oct. 26	Joint Pittsburgh District-SAE Meeting	Pittsburgh, Pa. (Mellon Institute)
Oct. 28	New England District	Cambridge, Mass. (Hotel Commander)
Nov. 15–17	Committee D-20 on Plastics	Cleveland, Ohio (Carter Hotel)
Nov. 16	Committee E-11 on Quality Control of Materials	Philadelphia, Pa. (ASTM Headquarters)
Nov. 17–19	Committee D-9 on Electrical Insulating Materials	Cleveland, Ohio (Carter Hotel)
Nov. 30	Northern California District	San Francisco, Calif.
Dec. 8	Western New York-Ontario District	Rome-Utica, N. Y., area
Dec. 9	Joint Western New York-Ontario District-ASM Meeting	Buffalo, N. Y.
Dec. 9–10	Committee D-21 on Wax Polishes and Related Materials	Washington, D. C. (Shoreham Hotel)

Standards Committee Acts on New Adhesives Test Method

On September 1, 1954, the Administrative Committee on Standards gave its approval to the Proposed Tentative Method of Testing Cross-Lap Specimens for Tensile Properties of Adhesives (D 1344–54 T).

This Tentative Method developed by ASTM Committee D-14 on Adhesives is intended to determine the comparative strength of adhesives by use of a cross-lap assembly under specific conditions of pretreatment, temperature, and testing machine speed. This test was especially designed for the adhesion of glass either to glass or to other materials and has been found sufficiently useful to warrant its publication as a tentative method.

ASTM Represented at Dedication of Historic Industrial Landmark

ASTM was officially represented at the dedication of the First Iron Works Restoration at Saugus, Mass., on September 17, by Carlton G. Lutts, chairman of the New England Council, who was accompanied by a number of other members of the Council.

The Restoration, which has been sponsored by the First Iron Works Assn., Inc., with financial support from the American Iron and Steel Inst., has unearthed and rebuilt America's three-centuries-old first successful iron works.

Visitors, who may now visit the Restoration where work still continues, may see the stone blast furnace, the Ironmaster's house, the partially completed forge building, and a museum housing hundreds of relics which have been unearthed as the work progressed.

ALL ITEMS ON STANDARDS BALLOT APPROVED

The canvass of the results of the 1954 letter ballot shows that the membership of the Society has approved all the items listed on the ballot. This included 89 revisions of existing standards, and 113 adoptions of tentatives as standards.

Details concerning these actions were given in the Summary of Proceedings of the Fifty-seventh Annual Meeting, which was mailed to all members in August, together with the letter ballots.

ACR Notes

Printed on behalf of the Administrative Committee on Research

Pessimism is apt to prevail when one considers the wide distribution of "Some Unsolved Problems" and the small percentage of replies received indicating to what extent work on particular problems might be picked up and developed. Occasionally, however, a letter is received which not only supports the morale of the Administrative Committee on Research, but indicates that we may look forward to progress on a number of the items included in the "Some Unsolved Problems" pamphlet.

The Director of Research of Physical Sciences at the Bell Telephone Laboratories, W. O. Baker, expresses the attitude of his organization as follows:

> "We have studied with interest your letter of July 28, 1953, to Dr. Buckley (who has now retired from the Laboratories) concerning the Program of the ASTM Administrative Committee on Research. As you know, our chemical and materials people work enthusiastically on nearly every ASTM committee, and, accordingly, your compilation of "Some Unsolved Problems" includes many which engage our own men. Actually, some work is going on here on about 35 per cent of all the items listed. Most of our results are promptly reported to suitable committees when solutions appropriate for ASTM action are obtained. Indeed, we expect to have reported significant progress on answers to questions you list for at least 30 per cent of the total, in the next few years.
>
> "This, you see, is only testimony to our belief in the soundness of your proposals and it might be interesting to have a check in the next three to five years to see how many of your total list of questions remain unanswered.
>
> "With respect to your final point about the suggestion of further problems, we shall of course continue to propose these through close association with the various ASTM working groups. Thank you for including us in your planning. Incidentally, in that connection, we have interpreted broadly this application of the term research, since most of the items would be properly designated applied research, or basic engineering in contrast to research, itself, in which detailed questions leading to specific results can seldom be phrased in advance."

Further support of the importance of ASTM research is evidenced by A. G. Ashcroft, Vice-President, Research and Development, Alexander Smith, Inc. Mr. Ashcroft was the 1954 recipient of the Harold DeWitt Smith Award, and in accepting this award spoke in part as follows:

> "He [Harold DeWitt Smith] recognized, as do all who support the work of the ASTM, the truth of Lord Kelvin's statement, 'When you can *measure* what you are speaking about and express it in numbers—you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science, whatever the matter be.' Dr. Smith recognized that the development of test methods and standards are the basic sources of all successful research and major developments in the textile industry. Several years ago, when I was serving as a member of the Board of Directors of ASTM, we asked the Research Directors of a score of companies, whose successful development of new fibers, processes, and fabrics was common knowledge, if they would trace for us the original source of these developments. Dozens of replies stated again and again that the source of their new knowledge, invention and commercial development began with a new test method usually here in the ASTM and these tests methods gave them, for the first time, quantitative measurements and thus confirming Kelvin's statement and the principles expressed in Smith's Marburg Lecture."

1955 Award of Merit Committee

With the acceptance of W. C. Clements and G. L. Werley, the personnel of the 1955 Award of Merit Committee is completed. These two men will serve with hold-over members, C. R. Stock (as chairman) and D. C. Scott, Jr. L. C. Beard, Jr. will represent the Board of Directors on this committee.

Surface Technology Research at NYU

A new laboratory for surface technology research has been opened in the Research Division of New York University's College of Engineering, Dr. Harold K. Work, director of the Division, has announced.

The new facility is located in Engineering Research Building No. 2 at 401 W. 205th St. in Manhattan.

Technical Committee Notes

Refractories

Work on Industrial Surveys Advanced

THERE was evidence of much standardization activity in the various fields of refractories, as reported at the meeting of Committee C-8 on Refractories, at Bedford Springs, Pa., on September 16. The committee met in advance of the Fall Meeting of the Refractories Division of The American Ceramic Society.

Additions to the group of industrial surveys, sponsored by the committee, were indicated. Surveys on clay linings, installation of refractories, and on carbon black furnaces are expected to be completed in the near future for inclusion in the next edition of the Refractories Manual. Surveys covering the paper and zinc industries are still needed.

Activity was reported in several of the sections on test methods. Research work is being conducted on the effect of the design factor on modulus of rupture of refractories. The temperature gradient problem as found in the load test is being circulated to several colleges as a proposed research problem. A proposed change in P.C.E. cone standardization resulting from a project at the National Bureau of Standards, is expected to be presented to the committee for consideration at its next meeting. This change will affect several of the present standards due to a realignment of the cone classifications.

Revisions in the methods for porosity and bulk densities which will generally improve the technique of these methods are being completed. A proposed tentative method of test for bulk density of granular refractory materials, which is in the form of a boiling test, was accepted for letter ballot of the committee. This method is for use with commercial products having particle size of three-mesh or coarser. Tentative revisions in the existing standards for castable refractories (C 268 and C 269) affecting the size of particles were approved. A report was made by the Section on Chemical Analysis, indicating cooperation with other committees interested in flame photometry. It is expected that a tentative procedure for the use of this type of analysis with refractories will be prepared.

In the field of heat transfer and thermal conductivity, it was indicated that attempts are still being made to set up ASTM apparatus in a consumer laboratory in order to obtain further data. The thermal conductivity method is also being considered in connection with the special refractories field, and tests are being run to obtain data.

The Standard Classification of Fireclay Refractories (C 27) is being considered for revision for the purpose of establishing fewer types. The classification of high alumina brick has been referred to the Special Refractories Assn. for recommendation. A test program has been agreed upon to determine the classification of silica brick, eight laboratories cooperating and using two series of brick. A special group is collecting data from manufacturers on methods to be used to classify ladle brick.

Projects being considered in connection with special refractories include the preparation of a load test in order to establish specification requirements, a thermal conductivity test, and classification of mullite and silicon carbide refractories. These problems are being studied jointly by the committee and the Special Refractories Assn. Both short and long-term load tests are being considered with small samples preferred.

Considerable activity is reported on basic granular refractories with test requirements set up on four classifications. A specification has been prepared which will be referred to the Subcommittee on Specifications for review. The proposed classifications are being referred to the Subcommittee on Classifications.

Concrete Pipe

Committee Reviews Tentatives for Adoption as Standards

THE first specifications in the pressure-pipe field were accepted for letter ballot by Committee C-13 on Concrete Pipe at its fruitful three-day meeting at the Ambassador Hotel in Chicago on September 9–11.

Two proposed tentative specifications were reviewed and final changes made at this meeting. One specification covers low-head reinforced concrete pressure pipe, intended for use in the construction of pressure conduits with low internal hydrostatic heads, generally not to exceed 100 ft. The other specification accepted is for reinforced concrete low-head internal pressure sewer pipe, to cover pipe 12 to 60 in. internal diameter and intended to be used for the conveyance of sewage, industrial waste, and storm water under internal operating head up to and including 50 ft.

Following a report of a special subcommittee appointed to study the need for a specification for precast manholes used for access to nonpressure lines, it was agreed to table further action on this development because of inconclusive results of the study. A questionnaire circulated among the concrete pipe producers indicated that although this type of unit has no uniform specification throughout the country, the performance has been satisfactory. Opinion was divided as to the need for an ASTM specification, particularly because the variation in design would present difficulties in formulating a national type of specification.

Considerable attention was given to a proposal for combining the two specifications on reinforced concrete pipe (C 75 and C 76). The special subcommittee appointed to study this combination reported that by close vote its members favored separate specifications, and it was the decision of the committee not to combine these two specifications at this time. The report of this subcommittee also included a comprehensive revision of the Specification for Reinforced Concrete Culvert Pipe (C 76), which will be distributed to the entire committee for consideration at the next meeting.

A considerable portion of the three-day meeting was occupied in reviewing all the numerous tentative revisions of standards that are now pending. After thorough discussion, the great majority of these tentative revisions were approved for adoption as standard in order that all of the standard specifications will appear in the latest revised form when included in the 1955 Book of Standards. In addition, there were

certain revisions in Specifications C 75 and C 76 accepted for immediate adoption, including a revision in the requirements for laps, welds, and spacing whereby the continuity of the circumferential steel shall be maintained.

For the first time, Committee C-13 will now operate under a set of regulations which were approved at this meeting, subject to confirming letter ballot. The regulations authorized an advisory subcommittee and certain standing subcommittees which it is expected will help to expedite the work of the committee, especially during the interim period between meetings.

Ceramic Whiteware and Similar Material

Nine New Tentative Test Methods Completed

ADDITIONAL coverage in standard test methods for evaluating whiteware products will result through action taken at the meeting of Committee C-21 at the Bedford Springs Hotel, Bedford Pa., on September 23. This meeting was held in advance of the combined Fall Meeting of the Whitewares and Materials and Equipment Divisions of The American Ceramic Society.

Nine proposed tentative methods of tests were presented: determining moisture expansion of fired whiteware products; flexure-testing fired dry pressed whiteware specimens at normal temperatures; determination of modulus of rupture of fired cast or extruded whiteware products; water absorption, bulk density, apparent porosity and apparent specific gravity of fired porous whiteware products; determination of resistance of ceramic tableware to impact apparent reflectance of glazed ceramic whiteware surfaces; resistance to impact of fired whiteware specimens; crazing resistance of fired glazed whiteware products; and determination of linear thermal expansion of fired whiteware products by the dilatometer method.

In addition, two new proposed methods were presented by the Subcommittee on Tests, subject to letter ballot of the subcommittee. These two methods include a procedure for determining the compressive strength of fired whiteware materials at normal temperature and a test outline for determining the thermal conductivity of whiteware ceramics. In the field of raw materials, several proposed methods are being prepared in the plastic and titinate groups.

The committee has developed an impressive list of definitions of terms in the ceramic whiteware field which has been published by the Society in tentative form. It is the expectation that the majority of these definitions will be recommended for adoption as standard by the time of the next Annual Meeting.

The Subcommittee on Research is concentrating at the present time on the problem of degree of vitrification and on subsieve particle size determination. A report was presented in the form of an illustrated talk on the results of research at Battelle Institute by A. K. Smalley, a member of the committee.

Atmospheric Sampling and Analysis

Four Methods Readied by Comparatively New Committee

WITH more than 65 per cent of the membership present at an all-day meeting on September 13, ASTM Committee D-22 held what was probably one of its most productive meetings since its establishment in 1951.

The results of the activity in this committee are now becoming apparent, four methods having been approved by the committee for submittal to the Society. A method for the determination of the concentration of odorous vapors by charcoal absorption has already been approved by the committee, and it is expected that it will be followed by an additional method for the determination of odor (dilution method).

The Subcommittee on Sampling Methods has developed, subject to approval by the main committee, "general principles of atmospheric sampling." This will be followed by formulation of specific techniques which will include: (*a*) sampling of gases, (*b*) sampling of particulate matter, (*c*) sampling for particle size, and (*d*) stack sampling.

The third method to be submitted to the Society is the method for determination of sulfur dioxide content by the electrolytic conductivity method. Subcommittee IV on Instrumentation, which developed this method, is considering two other methods for the determination of sulfur dioxide, a method for determination of gaseous fluorides, and an oxidant recorder. The determination of concentration of aerosols in submicron sizes is also receiving attention with respect to the use of a light-scattering photometer and paper filtration methods (moving tape type).

With any new committee, the establishment of nomenclature and terminology is of extreme importance, and Subcommittee I on Nomenclature and Units has kept pace with the other subcommittees in that some 60 of the terms pertaining to atmospheric sampling and analysis are now ready for submission to the Society for promulgation as an ASTM standard.

In addition to the two methods on odor referred to earlier, Subcommittee III on Analytical Methods is working on methods for determination of inorganic fluorides by the potassium iodide method, and the determination of nitrogen dioxide. There has been some discussion as to the need for methods for determining organic fluorides.

Cellulose and Cellulose Derivatives

Experimental Reports Feature Meeting

REPORTS concerning disperse viscosity of cellulose solutions, and chromatography as applied to the fractionation of wood pulps, were presented at the annual meeting of Committee D-23 in New York on Sept. 13, 1954, by W. E. Moore of the Forest Products Laboratory and B. L. Browning of the Institute of Paper Chemistry, respectively. The discussions which followed pointed up the committee interest concerning these lines of experimental work.

A detailed report of its progress on the color of chemical cellulose was presented, combined with a proposed general procedure for measuring color in chemical cellulose. This proposed procedure will be circulated for comment before formal action begins.

The final work on two methods measuring the degree of substitution and the viscosity of sodium carboxymethylcellulose is being completed. A method of testing cellulose acetate butyrate has now been assembled in proposed form for circulation within the subcommittee.

Studies concerning cold and hot alkali solubility, ash constituents, extractives, pentosans, and other areas of cellulose interest are rapidly progressing. A manual providing information concerning the statistical nature of cellulose sampling and interlaboratory tests is being produced for committee use.

Activities of Committee D-2 Summarized for June 1953 to June 1955

COMMITTEE D-2 has completed another very active year on the standardization of test methods and specifications for petroleum products and lubricants. More than 1500 people are connected in some way with the activities of the committee and its subcommittees. The purpose of this article is to present a summary of the work started or finished since June 1953, and a look at the projects planned for the next year, June 1954 to June 1955. The material was obtained from the subcommittee reports and is divided into sections on Engine Fuels, Lubricants, Other Products, Measurement and Sampling, and Analytical Methods. The article is by no means a complete presentation of all the work, since the subcommittees are very modest in reporting their progress.

ENGINE FUELS

Technical Committee A on Gasoline

H. M. Smith, chairman. The committee again examined ASTM Tentative Specifications for Gasoline. Octane numbers listed in the 1953–1954 National Winter Motor Gasoline Survey were reviewed. As a result, a recommendation was made to raise the research octane number one unit for regular and premium gasolines. Review of these surveys is a regular feature of the committee's work and will be continued. Other work planned for Specifications D 439 includes a study of vapor pressure requirements. Gasoline types A, B, and C will be retained. A survey will be made of the need for an ASTM Copper-Dish Gum Method.

A very successful Symposium on Gum and Storage Stability Characteristics of Motor Gasoline was held on Feb. 15, 1954, in Philadelphia.[1] Opinion developed by the symposium resulted in a decision to postpone work on a new gasoline stability test until more is known about the fundamentals of gasoline storage stability and its relationship to fuel performance. Liaison has been established with the Coordinating Research Council, Inc., and the Bureau of Ordnance who are doing work on storage stability.

The committee will continue to review Federal specifications for motor gasoline and keep the Government advised of the latest revisions in ASTM Specifications D 439.

[1] Two of the papers from this symposium, by Messrs. Donahue and Power appeared in the September, 1954, ASTM BULLETIN, see p. 58.

Technical Committee J on Aviation Fuels

J. T. Hendren, chairman. Specifications for Aviation Gasolines (D 910) were reviewed. This is a regular activity to insure their alignment with the requirements of present-day reciprocating engines. Color-standard samples for aviation gasoline grades 80–87, 91–98, 100–130, 108–135, and 115–145 were made available in 4-oz bottles instead of the 1-gal cans heretofore used. Standardization by ASTM of the copper-dish gum test, now a part of Specifications D 910, will be considered.

The increasing importance of jet fuels is reflected in the activities of the committee. Research Division III developed an amperometric method for mercaptan sulfur in jet fuels (D 1323). A test for smoke point of jet fuels (D 1322) was published as tentative this year.

A proposed method for filterability of jet fuels was published as information with the 1954 Report of Committee D-2. Research Division V on Analysis of Lubricants was asked to study the extraneous materials in jet fuels that make them hard to filter.

Technical Committee L on Tractor Fuels

E. M. Hughes, chairman. The Definition and Specifications for Farm Tractor Fuels (D 1215) were adopted as Standard.

Technical Committee F on Diesel Fuels

W. K. Simpson, chairman. A Symposium on Diesel Fuels was held on Feb. 17, 1954, in Philadelphia. Interest and attendance exceeded all expectations. The papers given have been published by ASTM in a special reprint.[2]

Although no items of work were completed, the committee is presently occupied with the following program:

1. D 975, Classification of Diesel Fuel Oils, will be reviewed. Changes in present temperature requirements for 90 per cent distilled are being considered.
2. Continued liaison with the Coordinating Research Council, Inc., is planned. The committee is particularly interested in the CRC projects on full-scale railroad tests of low and high cetane diesel fuels and the bomb-combustion studies of diesel fuels in progress at the Bureau of Mines.
3. Cooperation with the U. S. Navy will continue with regard to the volatility studies of submarine diesel fuels available at foreign ports.
4. A meter to measure smoking tendency of diesel fuel will be studied.

Research Division I on Combustion Characteristics

F. C. Burk, chairman. The Division has a program for improvement of engine Methods D 357, D 613, D 614, D 908, and D 909. These methods measure the knock characteristics of motor and aviation gasoline and the ignition quality of diesel fuel, which are very important in judging fuel performance in engines. The precision of the engine methods has been increased by an average of 17 per cent in the past five years when compared to the average for the previous five years. 279 laboratories and more than 650 persons are connected with the Division's work.

The detection of very small differences in the antiknock quality of *iso*octane and *n*-heptane is being studied. A survey was started of available equipment and techniques for rating small samples (50 to 100 ml).

[2] See p. 9.

Study continues on the application of the temperature-density concept to the Motor (D 357), Research (D 908), and Aviation (D 613) methods. Progress has been made on the reproducibility of Research ratings above 100 octane number.

The bouncing pin is no longer standard equipment for the Motor and Research methods. It has been replaced by the Detonation Meter.

Valve rotators were approved as preferred equipment for the Supercharge (D 909) method. Investigation showed that the rotators improve valve life and test engine operation.

Research Division V on Analysis of Fuels

C. A. Neusbaum, chairman. Revisions to Method D 381, Test for Existent Gum by Jet Evaporation, were approved. They provide a procedure for determining gum residue in gasoline that contains a lubricant.

The Division does a great deal of work at the request of Technical Committees of Committee D-2. Changes in the scope of the induction period method (D 525) will be proposed. An assignment was accepted from Technical Committee J to develop a method for determining which materials in jet fuels cause filter clogging.

A revision of Method D 95, Test for Water in Petroleum Products and Other Bituminous Materials, is being prepared in cooperation with ASTM Committee D-4 on Road and Paving Materials.

Research Division X on Corrosion Tests

F. D. Tuemmler, chairman. Method D 130, Test for Copper Corrosion by Petroleum Products, was revised. The most important change is the addition of a set of ASTM Copper Corrosion Standards, encased in plastic. The colored metal strips represent the degrees of tarnish, or corrosion, in accordance with the numbered scale in Method D 130. Sets of the standards can be ordered from ASTM Headquarters.

The revisions of Method D 130 also include a simple bomb test for copper corrosion by aviation gasoline. The bomb replaces the present, more elaborate, air-well apparatus. An effort will be made to improve the design of the bomb enclosure.

Development of a standard humidity-cabinet test is still active. An investigation of the variables inherent in the preparation of metal test panels will be scheduled. Elimination of these variables should result in a more precise test.

Research Division XI on Calorimetry

A. J. Kraemer, chairman. The Division is working on direct and indirect methods for heat of combustion of petroleum products. Revisions of Method D 240, Test for Heat of Combustion of Liquids by Bomb Calorimeter, have been distributed and discussed and will serve as the basis for a final proposal. A proposed indirect method has been prepared and will be submitted either for publication as information or as a new tentative.

A cooperative program to investigate one of the ten British standard calorimetry thermometers has just started. The British thermometers have smaller subdivisions and a narrower temperature range per thermometer than the ASTM calorimetry thermometer 56 C.

Research Division VIII on Volatility

R. J. Askevold, chairman. Some of the most important inspection tests used for petroleum products and lubricants (distillation, flash point, and vapor pressure) are maintained by this Division.

Additional descriptive material was added to the apparatus sections of Standard Distillation Methods D 86 (Gasoline, Kerosine, Naphtha), D 216 (Natural Gasoline), and D 158 (Gas Oil). Further revisions and the adoption of 125-ml flask are being considered. Distillation Method D 285 (Crude Petroleum) was revised editorially and reverted to Tentative.

The precision of the Standard Flash Point Methods D 56 (Tag Closed Tester), D 92 (Cleveland Open Cup), and D 93 (Pensky-Martins Closed Tester) will be established by cooperative tests. Other revisions are being reviewed.

In 1952, a proposed method for vapor pressure was published as information with the Report of Committee D-2. The method is similar to the vapor pressure standard, D 323, but measures vapor pressure with a null point indicator, instead of the Bourdon-type gages now prescribed. There is a small difference in the measured vapor pressures between the two methods. Variables thought to be responsible for this difference will be studied.

Method D 1267, Test for Vapor Pressure of Liquefied Petroleum Gases, may be revised to specify a definite temperature for determining 20 per cent outage. Work will depend on the opinion of Technical Committee H on Light Hydrocarbons.

The study of apparatus changes for Method D 1160, Test for Reduced Pressure Distillation, was completed. The changes called for a vacuum-jacketed column and mantle-type heater to replace presently specified equipment. A detailed report was published as information with the 1954 Report of Committee D-2. The new equipment did not improve the precision of Method D 1160. Further study and possible changes are planned.

LUBRICANTS

Technical Committee B on Lubricating Oils

W. S. James, chairman. A proposed viscosity classification system for industrial lubricants is being reviewed. The system was intended originally for gear lubricants. Because of the broad need for such a system for all industrial lubricants the scope has been extended. Tentative viscosity ranges are being considered by engineering societies, equipment builders, etc. The program will continue through 1955, since there probably will be a need for adjustment and compromise.

Work on crank case oils includes: (1) a test program to establish the precision of Method D 892, Test for Foaming Characteristics of Crankcase Oils, and (2) liaison with the Society of Automotive Engineers and the American Petroleum Institute on study of the API Lubricating Oil Service Classification.

The studies of extreme-pressure characteristics of railway car-journal oils are progressing. Cooperative testing of four railway car-journal oils on the Falex film-strength machine has been completed. The standard reference car-journal oil of The Association of American Railroads will be tested. An attempt will be made to correlate the Falex-tester results with full-scale performance tests.

Technical Committee C on Turbine Oils

F. C. Linn, chairman. The committee continued its program to develop and improve methods to evaluate rust prevention, oxidation resistance, emulsion and foam stability, and compatibility of turbine oils.

A proposed recommended practice for the design of turbine lubricating systems (2000 kw or over) has been prepared and will be referred to The American Society of Mechanical Engineers for publication. Work will start on the preparation of a recommended practice for the design of lubricating systems for smaller turbines (under 2000 kw, such as marine turbines). This program is a result of interest in the problem of rusting in these units.

Method D 665, Test for Rust-Preventing Characteristics of Steam-Turbine Oils in the Presence of Water, was made an ASTM Standard and recommended as an American Standard. The problem of rusting of turbine surfaces not frequently bathed in oil is receiving consideration. Attention will be directed toward the use of additional rust inhibitor to combat this type of rusting.

Method D 943, Test for Oxidation Characteristics of Inhibited Steam-Turbine Oils, was made an ASTM Standard and recommended as an American Standard. A symposium is being considered to discuss progress on the development of short-term oxidation tests, such as the rotary-bomb test.

An improved test for emulsion characteristics has been published as information in the 1954 Report of Committee D-2. Work on its precision is now in progress.

A proposed definition for *Compatibility* will be submitted to the Coordinating Division on Nomenclature (Committee D-2) for comment.

A study group was appointed to analyze and report on the problem of fire hazards in turbine lubricating systems.

Technical Committee G on Lubricating Grease

J. M. Bryant, chairman. A varied and interesting program is in progress. New tentative methods for leakage tendencies of greases, (D 1263), effect on copper (D 1261), water washout (D 1264), and lead in grease (D 1262) were published within the past year. A proposed method for functional life was published as information.

A Symposium on Shear Stability of Greases, sponsored by Technical Committee G, will be held at the Houston meeting during the week of Feb. 13, 1955.

A Symposium on Rapid Methods of Grease Evaluation from the Standpoint of Simulated Service will be held during the Annual Meeting of the Society, June, 1955 in Atlantic City.

Proposed methods for consistency and abrasion will be published as information in 1955. Sections of this very active committee are continuing their study of problems affecting the properties and uses of grease. This long-range work includes projects on compatibility, storage stability, noise level, and grease worker.

A new section will be formed to study dropping point methods that may supplement Method D 566, Test for Dropping Point of Lubricating Greases.

Research Division VI on Analysis of Lubricants

J. B. Rather, Jr., chairman. At the request of Technical Committee C on Turbine Oils, the Division has given its attention to the precision of Method D 974, Test for Neutralization Value (Acid and Base Numbers) by Color-Indicator Titration. Better precision is needed when the method is applied to new and used oils with neutralization values from 0 to 0.5 acid or base numbers. Revision of Saponification Methods D 94 and D 939 will be deferred until the program is finished.

Work continued on the preparation of a test for asphaltenes in new lubricating oils that contain residual stocks. This program, under way for four years, involves the possible use of pure hydrocarbons to replace precipitation naphtha. *N*-heptane and mixtures of heptane and cyclohexane have been tried. Other factors that have been studied are: solvent-sample ratio, method of heating to dissolve wax, heating time, and standing time for complete precipitation. Further work awaits clarification of the original assignment by Technical Committee B.

Method D 893, Test for Normal Pentane and Benzene Insolubles in Used Lubricating Oils, may be revised editorially.

The carbon residue Methods D 189 (Conradson) and D 524 (Ramsbottom) are receiving attention, particularly with respect to improving their precision in the low and high range of test results. Investigation of likely leads is being pursued, for the most part, on an independent basis in several laboratories.

Research Division VII on Flow Properties

J. C. Geniesse, chairman. Methods for viscosity, cloud point, and pour point of petroleum products and lubricants were reviewed. This year will mark the completion of the program started in 1952 to align ASTM viscosity methods and conversion tables with the value for the viscosity of water put into effect on July 1, 1953, by the National Bureau of Standards. The final item being prepared is the extensive and expanded Viscosity Index Tables with V.I. values calculated from basic kinematic values (in centistokes) for the ranges 0 to 150 V.I. and for kinematic viscosities at 210 F from 2.0 to 7.5 centistokes. These new V.I. Tables of approximately 850 pages, 7 by 10 in., with cloth cover are expected to be available by December.

The kinematic viscosity method (D 445) again lists the viscosity standards of the National Bureau of Standards. Minor editorial changes were also made in the method. To study the corrections involved in basic calibration of viscometers, master viscometers will be checked by a cooperative laboratory program. Results should be available sometime in 1955. API Viscosity Standard, "Gamma," may be given a value at −65 F to meet the need for accurate, low-temperature viscosity determinations. A Manual on Viscometry is being planned.

Cooperative tests have begun to establish the procedure and equipment for a proposed method to determine permanent viscosity loss of non-Newtonian liquids. It is hoped that the cooperative work will result in a suitable method by 1955. New developments in methods for determining temporary viscosity loss will be examined.

Cloud and pour point studies are being conducted as follows:

1. A test for pumpability of residual fuel oils is being developed to provide a better indication of pumpability than Method D 97, Cloud and Pour Points.
2. The stable pour point procedure (see Method D 97) is being studied to find a thermal cycle that will give good correlation with winter storage conditions.
3. A method to distinguish wax cloud point of fuel oils from water cloud point is being developed. Request for the work came from Technical Committee F on Diesel Fuel.
4. Standardization of pour baths, thermometers, and jars used in Method D 97 will be resumed.

Subcommittee on Extreme Pressure Properties Measurement

P. A. Asseff, chairman. The subcommittee has been testing liquid standards for calibration of the Timken extreme-pressure testing machine. The data obtained from the contributing laboratories vary widely. Machine condition and the surface finish of the test cups are considered to be important causes. These variables will be studied in a series of tests by using uniformly finished test cups with new machines and the machines used in the last program. The oils will be the liquid standards already tested.

A definition for *Load-Carrying Capacity* is being reviewed by other interested groups of Committee D-2: Technical Committee B, Technical Committee C, Technical Committee G, and the Coordinating Division on Nomenclature.

Research Division XII on Graphite Tests

H. J. Dawe, secretary. Proposed methods for the analysis of graphite, published for information in the 1953

Report of Committee D-2, will be studied and improved. Considerable work is being done on sieve analysis and sampling of graphite. Abrasion testing machines have been standardized in preparation for further cooperative work.

Proposed nomenclature and definitions of terms related to lubricating graphite are being reviewed by the Coordinating Division on Nomenclature.

Research Division IX on Color

H. M. Hancock, chairman. The Division is continuing its long-range program to develop an improved method for color of petroleum products. The method will employ a proposed new color scale and a colorimeter defined in terms of essential optical requirements. only. It should be in draft form by late 1954. Research Division IX was assisted in this work by the National Bureau of Standards and Hellige, Inc.

OTHER PRODUCTS

In addition to test methods for engine fuels and lubricants, Committee D-2 maintains an interest in and develops methods for a number of other important products such as light hydrocarbons, petroleum wax, cutting fluids, and plant spray oils.

Technical Committee H on Light Hydrocarbons

C. M. Heinen, chairman. Method D 1157, Test for Total Inhibitor Content of Butadiene, was revised and adopted as standard. The following work is in progress:

1. Review and improvement of methods for the analysis of butadiene.
2. Study of weathering, corrosion, moisture, and specific gravity tests for liquefied petroleum gas.
3. Methods for analysis of ethylene will be considered.

A Symposium on Test Methods for Liquefied Petroleum Gases was held Sept. 27 and 28, 1954, in St. Louis. Some 35 papers covering a wide variety of tests were presented. It is expected that the symposium will contribute much to future standardization work in Committee D-2. The symposium chairman was B. J. Heinrich, Phillips Petroleum Co., Bartlesville, Okla.

Technical Committee M on Petroleum Wax

G. C. Borden, chairman. This group functions as a joint committee with the Technical Association of the Pulp and Paper Industry. A long-range program is in progress to develop procedures for measuring the physical and functional properties of wax and wax coatings.

Although the committee has been working a comparatively short time, two methods have already been standardized and will be published by ASTM and TAPPI. They are for tensile strength (D 1320), and needle penetration (D 1321) of waxes. Further work on both methods is planned and includes studies of calibration procedures for the Tinius-Olsen tension tester, aging characteristics of tensile strength specimens after casting, and the bending type of tensile strength tests. Also, the precision of the needle penetration method will be reviewed for possible improvement.

The program of the committee also includes the following:

1. Submittal of a proposed test for oxygen stability to TAPPI as a suggested method. This test uses peroxide number as an indication of the onset of oxidation.
2. Consideration of other stability tests.
3. Study of two odor methods, one of which will be submitted to TAPPI as a suggested method.
4. Review of a gradient blocking point method, and methods for scuff, gloss, and sealing strength. Variables in the sealing strength test will be studied and attention is being given to development of a better instrument for measuring gloss.
5. ASTM Method D 87, Test for Melting Point of Paraffin Wax, is being tested to find out whether the stirring step is necessary.
6. TAPPI Method T 634 m-53, Melting Point of Petrolatum, may be extended to include petrolatums of high melting point, if an acceptable thermometer is found.

Technical Committee K on Cutting Fluids

E. M. Kipp, chairman. The committee has been attempting to develop methods to measure the effectiveness of cutting fluids and the analysis of their constituents.

A proposed method for active sulfur in cutting fluids will be offered to the ASTM Bulletin. A modification will be submitted for publication as information with the 1955 Report of Committee D-2. Development of a method for active chlorine in cutting fluids is under study.

The long-range program to develop a method to evaluate cutting fluids by flank wear and finish tests is continuing. Improvements in the procedure will be investigated by further cooperative tests.

A proposed method for emulsion stability of water-soluble oil will be offered to the ASTM Bulletin. A modification will be submitted for publication as information with the 1955 Report of Committee D-2. A method for rusting characteristics of water emulsions of soluble oils is being developed.

The characteristics of the Falex extreme-pressure test machine will be evaluated by use of special test and selected cutting fluids. It is hoped that a good laboratory film strength test can be developed. The present program is oriented to this end rather than to the development of a method that will predict field performance in service.

In addition to the laboratory program, the committee has a program to evaluate cutting fluids in industrial plants. Oils and equipment have been selected, assembled, and shipped to those who are cooperating in the program. Final instructions will be issued to all participants.

Subcommittee XVII on Plant Spray Oil Tests

L. Mittelman, chairman. Changes in the shaking apparatus of Method D 483, Test for Unsulfonated Residue of Plant Spray Oils, are under consideration.

Also the distillation flask used in Method D 447, Distillation of Plant Spray Oils, may be changed to conform with the flask in Method D 158, Distillation of Gas Oil and Similar Distillate Fuel Oils. The two flasks differ only in the length of their vapor tubes.

MEASUREMENT AND SAMPLING

Division II on Measurement and Sampling

C. A. Neusbaum, chairman. An active year of work resulted in the following changes in the standards under the Division's jurisdiction:

1. Method D 287, Gravity of Petroleum and Petroleum Products, was replaced by separate Standards for determining specific gravity (D 1298), and API gravity (D 287).
2. Method D 1086, Measurement of Temperature of Petroleum and Petroleum Products, was revised editorially. Other revisions are under consideration and have been published as information. They deal with the design, specification, and operation of electrical-resistance thermometers. New and improved types of manual equipment for temperature measurement are also being studied. They include plastic cup-case thermometers, bi-metal actuated thermometers, and mercury thermometers with larger graduations.
3. Further study and review of the

American Standard ASTM-IP Petroleum Measurement Tables (ASTM D 1250; IP 200, ASA Z11.83) resulted in supplements to Tables 6 and 7 (Reduction of Volume to 60 F Against API Gravity to 60 F) covering volume correction factors for temperature ranges from 0 to −50 F. An abridged table of volume correction factors for liquefied petroleum gases (Table 32) was published. Table 5, Reduction of Observed API Gravity to API Gravity at 60 F, was made available as a wall chart.

4. Cooperative work with the Institute of Petroleum (London) is being continued. Additional tables will be prepared as needed by industry. Work in progress includes an expansion of Table 5 for entry at each 0.1 deg of observed API gravity; revision of the introductions to the individual tables so that API gravity is expressed to one decimal place; consideration of a table of conversion factors from API gravity to long tons per 1000 cu ft and per cubic meter; and a study of the need for tables that list volume corrections for waxes, aromatics, and certain petrochemicals. The first printing of the ASTM-IP Petroleum Measurement Tables, American Edition, was completely sold out, requiring a second printing. The sale of the tables has been a source of satisfaction to the Division and Committee D-2 and to those of its members who contributed so freely of time and effort in their preparation.

5. The comprehensive Methods D 1220, Tank Calibration of Upright Tanks, were published as a separate reprint. Procedures for calibration of spheres and spheroids have been completed and are now out to letter ballot of the Division. The calibration of horizontal steel tanks (mobile and stationary), barge tanks, ship cargo tanks, and tank cars is being studied.

6. Revisions of Methods D 270, Sampling Petroleum and Petroleum Products, were published as information. They cover flushing of sample containers and sampling of package shipments. Automatic devices for sampling, gaging, and temperature determination are being studied.

7. Revisions to D 1087, Volume Calculations and Corrections, are being considered. The purpose is to clarify the procedure for ascertaining the number of significant figures in calculations of bulk-oil quantities.

8. Other items being studied include procedures for gaging new tank designs; the effect of line displacement on quantity measurement; and methods for determining the specific gravity of liquefied petroleum gases by hydrometer or pycnometer.

ANALYTICAL METHODS

In addition to the Research Divisions on Analysis of Fuels and Analysis of Lubricants, there are two other Divisions whose activities concern analytical methods that pertain to the whole range of petroleum products under the jurisdiction of Committee D-2.

Research Division III on Elemental Analysis

C. M. Gambrill, chairman. An active program is in progress to determine sulfur, chlorine, phosphorus, carbon, hydrogen, oxygen, nitrogen, metals, trace elements, and tetraethyllead in petroleum products and lubricants.

Two new methods for mercaptan sulfur were standardized. They utilize amperometric (D 1323) and potentiometric (published as information) procedures. A study of rapid combustion methods for the determination of sulfur in lubricating and heavy fuel oils will continue. The effects of tetraethyllead on sulfur determinations will be studied. Burners for aromatic concentrates are being investigated.

The sodium-alcoholate method for chlorine in oils and greases (D 1317) was published as tentative. A cooperative program will check results by this method with those given by the bomb method, D 808. The program is designed to determine which method will be recommended for adoption as standard.

A section on precision was written into Method D 1091, Test for Phosphorus in Lubricating Oil, Lubricating Oil Additives, and Their Concentrates. The Division is considering the method for adoption as standard. Technical Committee A will be canvassed to find out the need for methods to determine phosphorus in gasoline and several are being studied. During the year, efforts were continued on preparation of methods for the direct determination of calcium, barium, and zinc in new lubricating oils. A polarographic procedure for zinc was investigated by a cooperative test program. Flame photometric tests for barium and calcium will be studied by special groups.

A test for sodium in residual fuels by flame photometer (D 1318) was published as tentative. A modification of the procedure that calls for direct burning of the sample rather than atomization of the sample ash is being studied. Colorimetric and photometric methods for vanadium in residual fuel oils are being developed.

At the request of Research Division I, a program has been launched to develop a test method for determining trace amounts of lead in the primary reference fuels. Results of a preliminary cooperative program indicate that Method D 1269, Test for Polarographic Determina-

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tion of Tetraethyllead in Gasoline, and a proposed polarographic method using the TEL-Meter have good precision. Shortcut methods for the extraction of tetraethyllead were investigated. A cooperative test program will be started to compare the precision of the short-cut extraction and polarographic methods. It should determine what future action is needed. The Institute of Petroleum (London) is interested in the polarographic methods and will be kept advised of the results of the program.

A revision to the precision section of Method D 1018, Test for Hydrogen in Petroleum Fractions by the Lamp Method, is being considered. Data on the beta-ray hydrogen method will be solicited for review.

The groups investigating the spectrographic analysis of used diesel lubricating oils have been particularly active. Their work has been incorporated under a new section called Section J on Spectrographic Analyses of Lubricating Oil. Spectrographic methods and sampling procedures for diesel engine lubricating oils are being studied. A recommended oil sampling procedure should be available by June, 1955.

Research Division IV on Hydrocarbon Analysis

W. E. Scovill, chairman. Two new sections were organized during the year: J on the Analysis of Reference Fuels, and K on Correlative Methods for Hydrocarbon Type Analysis.

A revision of Method D 1019, Test for Olefinic Plus Aromatic Hydrocarbons in Petroleum Distillates, is under consideration which specifies test mixtures as criteria of adequate shaking.

The Division cooperated with ASTM Committee D-16 on Industrial Aromatic Hydrocarbons in developing a bromine index method for determining total olefins in industrial aromatic hydrocarbons. A program was undertaken to establish the use of Methods D 1158 and D 1159 (Bromine Number of Petroleum Distillates) in determinations of the purity of polymeric materials. Results indicated that special test conditions are necessary. The variables involved in bromine number tests are being investigated. IP Methods corresponding to ASTM Methods D 1158 and D 1159 will be tried to see whether they give equivalent results.

The fluorescent indicator adsorption (FIA) method for hydrocarbon types in liquid petroleum products (D 1319) was published as tentative. This includes a procedure for debutanized distillate fuels that boil below 600 F, which was not in the method as published as information in 1952. Efforts will be made to improve the precision of the method and to extend its applicability to other petroleum products. Reported differences in result between Method D 1019, Test Olefinc Plus Aromatic Hydrocarbons in Petroleum Distillates, and the new FIA method will be investigated.

The program to develop a method of test for the determination of refractive index of petroleum products, particularly waxes, at 80 and 100 C is continuing. Methods for density at elevated temperatures will also be studied. Method D 1217, Test for Density and Specific Gravity of Liquids by the Bingham Pycnometer, was adopted as standard. Revisions under consideration for Method D 941, Test for Density of Hydrocarbon Liquids by the Pycnometer, provide a procedure for converting density to specific gravity. Also, revisions of Method D 1218, Refractive Index and Refractive Dispersion of Hydrocarbon Liquids, are planned, to include other five-place refractometers. A four-place refractive index method is being studied.

Methods D 1016, Test for Determination of Purity from Freezing Points, and Method D 1015, Measurement of Freezing Points for Evaluation of Purity, were reviewed. A procedure for determining purity of samples of *n*-octane was added to Method D 1016. Short-cut methods for freezing point and purity of samples of commercial *iso* octane were evaluated but no changes were made in the ASTM methods. Details of a drying procedure will be added to D 1015; reference to the procedure will be made in the appropriate places in D 1016.

Methods D 1095, Analysis of 60 Octane Number Reference Fuel Blends, and D 1096, Test for 1,3, Butadiene in C_4 Hydrocarbon Mixtures by Ultraviolet Spectrophotometry, were adopted as Standard.

A proposed method for the determination of individual hydrocarbons in a C_4 fraction by infrared spectrophotometry was published as information. Additional data on precision will be obtained before the method is recommended.

Plans are being developed for the publication of an ASTM Manual on Hydrocarbon Analysis. The purpose of the manual is to collect under one cover the recommended procedures for the analysis of hydrocarbons. The Manual will contain existing ASTM methods on hydrocarbons analysis and related material.

Work is continuing on the analysis of the reference fuels used in the ASTM engine test methods. Future work will be directed toward development of a method to isolate and secure additional information on the nature of hydrocarbon impurities present in reference fuels. Separation and concentration techniques will be tried.

Work will be done to formulate methods for the determination of molecular weight of hydrocarbon compounds by direct and correlative techniques.

Mention should be made of the continuing program to coordinate the work being done in Committee D-2 with the work of the Institute of Petroleum.

In addition, contact has been established with the Fachausschuss Mineralol- und Brennstoffnormung, Hamburg, West Germany, and the Bureau de Normalisation du Petrole, Paris, France.

To ASTM Nonmembers: The Society welcomes inquiries on the "Advantages of Membership"

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Random Samples . . .

FROM THE CURRENT MATERIALS NEWS

From the broad stream of current materials information flowing from "in-box" to "out-box" in a busy editorial office, random samples (mostly random) have been plucked. Thinking them worth re-showing to ASTM'ers who may have missed the original articles, we have included them here. Of course, we had to trim the samples to fit. There will be those who are not satisfied with samples, especially ones which are not really random. But these ASTM'ers can contact the institution, magazine, governmental agency, etc., who placed the original information in the stream. We have quoted literally, sometimes without quotation marks where the point of omission is obvious, and we have given credit to the source. These credit lines are also for the use of ASTM'ers whose entire curiosity has been aroused.

Portable Pipeline

A NEW cost-saving tool for engineering contractors, the portable aluminum pipeline, is receiving a rigorous test during construction of the $34,000,000 Roanoke Rapids Dam project of the Virginia Electric and Power Co. in North Carolina, Aluminum Company of America Report.

Approximately 8500 ft of 6-in. aluminum pipe is being used to supply compressed air to the wagon drills of Central Engineering and Contracting Corp. This subcontractor is engaged in excavating over 1,000,000 cu yd of solid rock to form the 8000-ft long tail race for the dam.

The light weight of the aluminum pipe, and the ease of coupling and uncoupling, allow distinct cost savings in moving the air line as the job progresses. A 20-ft length of this 6-in. pipe weighs only 27 lb and can easily be handled and connected by one man.

Central Engineering and Contracting uses as many as six, 600-cfm diesel-powered air compressors to feed air to one of the several aluminum lines used. With an air pressure of approximately 105 psi in the line, 8 to 10 wagon drills simultaneously get their source of power through the aluminum pipe.

The aluminum lines are also used to supply compressed air to a special "drill jumbo." This unit consists of 14 drills assembled in a single rig that will allow simultaneous drilling of 14 holes. By speeding up the drilling operation, blasting and grading can in turn be accomplished more rapidly.

Fast coupling and uncoupling of the aluminum lines is made possible with special aluminum alloy couplings. To connect the air lines with these couplings, sections of pipe are inserted in each end of the coupling and a locking pin is slipped into the coupling. A sleeve with an arm is attached to each end of the pipe sections to provide a means of attachment to the coupling. The pin when inserted attaches the arms to the coupling.

While this type of aluminum line is a new development in piping water or compressed air for construction work, it has had long and successful use on the farm for portable irrigation. Aluminum irrigation pipe, used with a type of coupling similar to the one described above has had widespread use by farmers since World War II. Approximately 30,000 miles of aluminum pipe have been sold for this application.

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Uranium Research Encouraged

To date, most research on the metallurgy of uranium and its alloys has been done at the major AEC laboratories under the usual security conditions. However, it is not generally realized that there are many fundamental research projects that can be performed on an unclassified basis. For example, studies of constitution diagrams and crystal structure electronics structure, mechanisms of corrosion, thermodynamics, phase transformations, electrochemical studies, and other basic research on uranium and its alloys can be performed as unclassified research.

Work may be carried out under these general principles: First, any subject for research must have the approval of the AEC's Office of Classification, and a license must be obtained for purchase of natural uranium if more than three pounds are to be used. The metal is unclassified, however, and need only be accounted for on the basis of its monetary value. Second, a project leader must generally be given a security clearance so that he may learn what information might be classified and be able to recognize and secure classified information should it unexpectedly be developed. Third, technical reports, although nominally unclassified must be reviewed by AEC before publication. Experience to date indicates that delays or deletions as a result of such review are exceedingly rare, however.

University research groups are urged to study in these fields and the AEC has indicated willingness to provide financial support (as funds are available) to worthy research projects, or to provide necessary small amounts of natural uranium free of charge in return for information developed. Further inquiry should be made to the AEC's Division of Research, Washington 25, D. C.

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More Low-Temperature Problems

Low-temperature liquefied gases are finding increased application in industry and national defense, making necessary larger, more convenient, and less hazardous equipment for producing and handling them. As a result, many new and highly complex engineering problems have arisen in the low-temperature field, where much remains to be learned about the mechanical and thermal behavior of engineering materials and the nature of the processes. There are such marked differences between the behavior of matter at ordinary and very low temperatures that the low-temperature properties cannot generally be obtained by extrapolation. Although low-temperature processes have been very useful in the past, further studies of the processes promise to be very fruitful. The NBS-AEC Cryogenic Engineering Laboratory has been engaged in this type of research and development since its inception in 1951.

The 1954 Conference on Cryogenic Engineering was held September 8, 9 and 10 under the sponsorship of the National Bureau of Standards at the NBS-AEC Cryogenic Engineering Laboratory in Boulder, Colo. The first meeting of its kind in this important new field, the Conference treated engineering problems in the temperature range below 150 K (−123 C). Technical papers dealt chiefly with problems encountered in the production, storage, transportation, and use of low-temperature liquefied gases—hydrogen, nitrogen, and oxygen.

In addition to the technical sessions, the Conference on Cryogenic Engineering participated in the official dedication of the National Bureau of Standards Boulder Laboratories on September 11, 1954.

Fire-Resistant Coating

A HIGHLY soluble borate, especially adapted for the preparation of washable fire-resistant coatings, has been developed by American Potash and Chemical Corp.

The borate, named "Borotherm," is described as inexpensive and relatively neutral and is intended for use with water-based coatings. It offers important advantages not now available in coatings of this type.

The primary function of Borotherm is to give fire-resistant properties to coatings to meet Department of Commerce specification CS-42-49 (Class F) and Federal Specification SSA-118-a when used with latices and dispersions. It is especially adaptable for use with coating grade polyvinyl acetate.

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Solution Ceramics

NEW flexible coatings which can be applied to any clean, solid surface at a few hundred degrees Fahrenheit have been developed by Armour Research Foundation of Illinois Institute of Technology.

Called "solution" ceramics because they are applied from chemical solutions, the new coatings do not contain any adhesive or binding agent and are not brittle.

Thickness of these coatings can be accurately controlled—a film as thick as 0.01 in. can be deposited and some coatings only a few millionths of an inch thick have been made. Most solution ceramics are so adherent to the surface of the underlying material that other coatings can be anchored to them.

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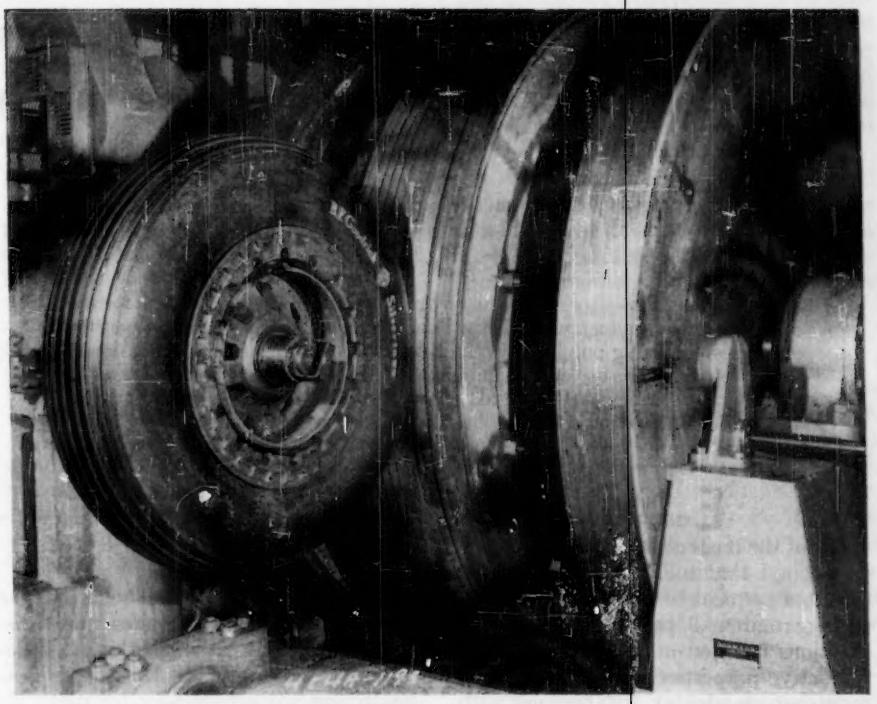
Better Tails

A NEW and practical use has been found for stainless steel tubing. For the first time, an automobile manufacturer is using stainless tubing for the entire extension assembly muffler and tail pipe on a 1954 model car.

Making the twin assemblies from stainless steel is said to give them more resistance to rust formation, chemical attack, and subsequent corrosion. The tubing is subjected to acids formed by exhaust gases, salt poured on the streets during the winter, and temperatures up to 800 F.

Hot-rolled steel, used in ordinary assemblies, costs less than the stainless steel. But the stainless tubing offers the double advantage of longer wear and bright appearance. It is also considered stronger mechanically.



The airplane brake-testing machine shown above was recently installed at the B. F. Goodrich wheel and brake plant at Troy, Ohio. The machine presently has a top speed of 246 mph with provision for future speeds up to 300 mph. A wheel loaded to 70,000 lb and traveling at 246 mph can be tested on the new dynamometer, such tests simulating stresses sustained by wheels and brakes in landing and stopping safely today's giant planes whose individual wheels must support loads up to 25 tons. The new machine, which weighs 113 tons and stands 9 ft high, will be the only dynamometer equipped with apparatus to supplement the effects of windage and aerodynamic drag met in actual aircraft landings. The 56 by 16 aeronautical tire shown above was traveling at 100 mph when this picture was taken with stroboscopic lights at 1/300,000 of a second. Goodrich makes this tire, wheel, and brake for use on the Boeing B-52 intercontinental bomber.

Reinforced Plastics Group Formed in Committee D-20

A NEW subcommittee of ASTM Committee D-20 on Plastics is being organized under the chairmanship of Ray B. Crepps to study the basic properties of reinforced plastics which are used in such applications as automobiles, boats, building panels, railroad cars, and other uses where a reinforced plastic with structural properties is desirable. A meeting of the Steering Committee of the subcommittee was held on September 16 at the National Bureau of Standards in Washington to outline operational plans and procedures for its technical work. Consideration was given to the setting up of sections on flat sheets, rods and tubes, corrugated sheets, and constituent materials.

The next meeting of the Subcommittee will be held at the Carter Hotel, Cleveland, Nov. 15–17, 1954. Interested producers and consumers of reinforced plastics may write for information to Ray B. Crepps, Owens-Corning Fiberglas Corp., Research Laboratories, Newark, Ohio.

GSA Standards Help Taxpayer

THE General Services Administration has added 13 groups of items to the list of supplies and equipment standardized for Government use.

Agencies may now buy only 17 different kinds of mimeograph paper instead of 172; three kinds of general lead pencils instead of 11, and five kinds of executive office desks instead of the previously allowed 28. Standardization of mimeograph paper alone is expected to save the Government about a million dollars a year.

Experience since last September with standards issued at that time shows that standards on office furniture will save at the rate of $2,700,000 per year based on purchases of $18,000,000 annually for all agencies. Over-all purchases of new furniture have dropped well below this figure because of additional efforts by GSA to concentrate on utilizing available stocks rather than making new purchases.

Standards on janitorial and administrative supplies are saving about $300,000 per year based on purchase of $3,000,000 annually.

Analysis for Molybdenum-Bearing Austenitic Stainless Steel Proposed for Experimental Use in Chemical and Process Industries

By W. R. Myers[1]

THE accompanying article, prepared by Mr. Myers for the ASA Chemical Industry Advisory Board Subcommittee on Stainless Steel Analyses,* is being published in the BULLETIN as information. Comments are solicited for the use of the committee which will have this proposal under consideration, since the suggested composition may eventually be incorporated into an existing specification or used as the basis for preparing a new specification.

EARLY in the development of the austenitic stainless steels, it was found that molybdenum additions of 3 to 4 per cent to the standard 18 per cent chromium–8 per cent nickel compositions resulted in steels having very attractive properties from the corrosion resistance standpoint. Experience with the molybdenum-modified grades during the past 25 years has demonstrated their usefulness for construction of chemical process equipment in the following general fields:

1. Organic syntheses and processing, particularly those involving organic acids of relatively low molecular weight.
2. Certain inorganic processes requiring more resistant material than the nonmolybdenum bearing grades. For example, the molybdenum bearing grades have proved useful in handling certain concentrations of phosphoric, sulfuric, and chromic acid as well as mixtures of nitric-hydrofluoric.
3. Processes and service conditions requiring greater resistance to pitting than that obtainable with the nonmolybdenum-bearing grades of stainless steel.
4. High-temperature service where greater creep strength is required than is obtainable from the molybdenum-free types of 18–8 steels.

It is in the above general fields that the molybdenum-bearing grades fill a distinct need, and in which the molybdenum-free grades of the 18–8 types generally are not satisfactory for use.

The first molybdenum-modified austenitic stainless steels used in this country were of foreign origin or were made to foreign specifications by our domestic steelmakers. These steels generally conformed to the Krupp analysis and specifications, and were frequently known by the designation KA2S-Mo.

Metallurgically the early compositions were unbalanced with respect to the austenitic phase and metallographically consisted of both austenite and ferrite phases. This imposed severe limitations on the hot-working characteristics of the alloys. The manufacturers of seamless tubular products in particular were unable to handle the steels successfully. This led to development work aimed at producing compositions which could be worked and processed and still retain the desirable characteristics of the original alloys. This work resulted eventually in our present AISI Type 316 and AISI Type TP 316.

The compositions of the present AISI grades of molybdenum-bearing austenitic steels are given in Table I.

A large segment of the chemical industry does not use steels conforming to the analyses given in Table I, but purchase many modified varieties. The modifications usually place special restrictions on the carbon, nickel, chromium, or molybdenum contents.

A subcommittee of the ASA Chemical Industry Advisory Board completed a survey recently of the practices of 32 companies which represent a broad segment of the chemical industry. The committee found that nine of the companies use standard AISI compositions and have no present interest in modifications. Ten companies purchase to their own individual specifications which differ from present AISI compositions. The remainder follow various practices, the majority using AISI specifications with restrictions of 0.03 per cent max or 0.06 per cent max in the carbon content. One company, however, uses Type 317 exclusively with a restriction of 0.03 per cent max and 0.06 per cent max on the carbon. Another company specifies a maximum nickel content of 12 per cent, whereas a number of the consumers specify minimum nickel contents ranging up to 12 per cent.

The survey revealed the significant fact that the bulk of the molybdenum-modified austenitic stainless steel used by the chemical industry conforms to AISI Type 316 or one of its several modifications. There is a relatively small tonnage of the higher molybdenum grade (317) employed. This may be attributable to Government restrictions imposed at various times during the past 10 years. On the other hand, the chemical industry has learned that in a large majority of cases a molybdenum content of 1.75 to 2.00 per cent is adequate.

Several favorable advantages would accrue from the adoption of a standard analysis for the molybdenum-containing austenitic stainless steel by the chemical industry. Aside from the possibility

TABLE I.—COMPOSITION OF AISI GRADES.

	Chemical Composition, per cent		
	AISI Type 316	AISI Type TP 316	AISI Type 317
Carbon	0.10 max	0.08 max	0.10 max
Manganese	2.00 max	2.00 max	2.00 max
Silicon	1.00 max	0.75 max	1.00 max
Phosphorus	0.04 max	0.04 max	0.04 max
Sulfur	0.03 max	0.03 max	0.03 max
Chromium	16.00 to 18.00	16.00 to 18.00	18.00 to 20.00
Nickel	10.00 to 14.00	11.00 to 14.00	11.00 to 14.00
Molybdenum	2.00 to 3.00	2.00 to 3.00	3.00 to 4.00

[1] E. I. du Pont de Nemours & Co., Inc.

* The membership of the ASA Chemical Industry Advisory Board Subcommittee on Stainless Steel Analyses is as follows: J. G. Henderson (chairman), Carbide and Carbon Chemicals Co.; L. G. Haller, Tennessee Eastman Co.; W. R. Myers, E. I. du Pont de Nemours & Co., Inc.; W. B. Pierce, Allegheny Ludlum Steel Corp. J. J. B. Rutherford, The Babcock & Wilcox Co.; G. A. Sands, Electro Metallurgical Co.; H. B. Warner, B. F. Goodrich Chemical Co.; G. C. Whitaker, Harshaw Chemical Co.; and Frank L. Whitney, Jr., Monsanto Chemical Co.

The following alternate members entered into discussions at specific meetings of the subcommittee: Russel Franks for G. A. Sands; H. L. Priestley for G. A. Sands; G. C. Kiefer for W. B. Pierce; R. C. Thumser for Frank L. Whitney, Jr.; H. L. Maxwell for W. R. Myers; J. F. Beck for J. J. B. Rutherford; and M. B. Conviser for L. G. Haller.

of more economic use of our available nickel, chromium, and molybdenum, the steel producers would not be required to produce such a variety of analyses and modifications, and warehouse stocks could be used to better advantage by the consumers. Standardization would also simplify regulations covering construction of pressure vessels made of molybdenum-modified stainless steel.

The special subcommittee, after a thorough study of the requirements of the chemical industry, selected the following tentative composition which is believed to be suitable for at least 80 per cent of the tonnage purchased by the chemical industry.

Proposed Tentative Analysis

Carbon, per cent	0.07 max
Manganese, per cent	2.00 max
Silicon, per cent	1.00 max
Phosphorus, per cent	0.040 max
Sulfur, per cent	0.030 max
Chromium, per cent	17.5 min
Nickel, per cent	9.5 to 12.5
Molybdenum, per cent	2.25 min

The following resolution was adopted unanimously by the subcommittee:

"RESOLUTION

"That the adjusted analysis tabulated as a part of the immediately preceding paragraph (see analysis above) be proposed for ultimate approval and adoption by the chemical and process industries, such approval and adoption to be predicated upon experience data developed by a broad section of separate companies who would agree to accept the analysis as proposed or as might be further modified by industry consensus following the development of a satisfactory order of experience data, and that such acceptance be construed as signifying substantial acceptance by the individual consuming companies of the new analysis for application, without additional modifications, in the broad field of applications currently served by AISI Type 316 or any of the many private modifications thereof, to the ultimate end that a more satisfactory standard analysis might be established, and might be recognized not only by the consuming industry but also by the American Iron and Steel Institute, the American Society for Testing Materials and, finally, the American Standards Association."

In motivation of the resolution it was agreed (*a*) that the proposed analysis be thoroughly publicized to all segments of industry considered as having interests in the project, including especially consuming chemical and processing companies and the producers that serve their needs; (*b*) that the producing mills make available semifinished or finished products from mill heats of the proposed analysis, such products to be used experimentally or on a trial basis by the consumer to prove or disprove acceptability of the analysis. It is anticipated that the demand for experimental heats will develop from effective publication of the findings of the subcommittee; (*c*) that consuming companies be urged to agree to procure and use products made from heats of the proposed analysis and, if found acceptable, that the consumer agree to specify the new grade wherever reasonably possible, and without modification; and (*d*) that, following the eventuality of substantial acceptance, the proposed analysis be submitted to appropriate standardization agencies with a recommendation that it be made American Standard (AISI, ASTM, etc.).

The Subcommittee Report, its Resolution, and points of motivation of that Resolution, all as outlined in the foregoing, were subsequently approved by the ASA Chemical Industry Advisory Board.

It is the consensus of the subcommittee that the tentative analysis, if proved satisfactory by experience, ultimately should become a new standard grade, and, insofar as the chemical industry is concerned, is not intended to replace the present AISI Types 316 or 317.

Corrosion of Nickel Cast Irons in Soils

THE National Bureau of Standards has completed a long-range study of the effects of corrosion of varying amounts of nickel in cast iron in soils.

Corrosion of cast iron in soil is characterized by the development of an adherent layer of corrosion products that increases in thickness as corrosion progresses. Thickening of this layer is due in part to electrochemical action between the ferritic and graphitic constituents of cast iron and partly to differences in potential that arise from contact of the metal with the soil.

Sixteen exposure sites were employed, representing a wide variety of United States soils. The study included samples of plain cast iron, low-alloy cast iron pipe (1.27 Ni, 0.32 Cu; 1.17 Ni, 0.98 Cu; 3.32 Ni), low-alloy cast iron plate (2.08 Ni, 1.10 Cu; 3.10 Ni), and specimens of high-alloy cast iron pipe (15.0 Ni, 6.6 Cu, 2.6 Cr). The specimens consisted of lengths of pipe 10 to 14 in. long and 1.5 to 2.5 in. in diameter. Moisture was excluded from the interior by means of screw caps and by coating with heavy grease.

Weight losses and depth of pitting were correlated with the composition of the specimens and the type of soil to which they were exposed. From the standpoint of both criteria, the high-alloy cast iron was considerably more resistant to corrosion than either the plain cast iron or the low-alloy cast irons. Except in cinders, the deepest pit measured on the high-alloy specimens was only 74 mils after 14 years of exposure.

In the low-alloy cast irons, additions of nickel up to 3 per cent were found to reduce initial corrosion in poorly drained soils of low resistivity, but this advantage was not maintained for the duration of the tests. Thus, the weight losses of the low-alloy cast irons exposed for the maximum period did not differ greatly from the losses of the plain cast iron. Hence, it would appear that the rates of corrosion of the alloys containing as high as 3 per cent nickel decrease less with time than do the rates for plain cast iron and the alloys containing smaller amounts of nickel.

Measurements of hydraulic bursting pressure were also made on samples of the nickel cast irons after exposure to different soils. It is generally recognized that corroded cast iron retains some of its original strength, but the extent to which cast iron pipe may corrode underground and still retain sufficient strength to withstand pressure commonly used in water and gas distribution systems had not previously been estimated. In order to evaluate this residual strength, samples of pipe removed from the more corrosive soils after the longer periods of exposure were subjected to hydraulic pressures increased at the rate of approximately 10 psi per sec until failure of the pipe occurred or the maximum pressure of 500 psi was attained. Corrosion products were then removed and the condition of the specimens evaluated.

After exposure at the test sites for periods up to 11 years and laboratory storage for approximately one year, most of the specimens withstood a maximum pressure of 500 psi, even though removal of the corrosion products revealed numerous holes. Most of the low values of bursting strength obtained probably were not accurate measures of the strength of the corroded pipe at the time of its removal from the soil since these low values may have resulted from oxidation of the corrosion products during storage or damage in shipment. Hence, it is reasonable to assume that undisturbed buried cast iron pipe, even in an advanced state of graphitic corrosion, is able to withstand the minimum pressure required of class 150 pipe.

Errors Occurring in the Measurement of Dielectric Constant

By Robert F. Field*

THE dielectric constant of an insulating material is the ratio of the parallel capacitance, C_p, of a given configuration of electrodes with the material as the dielectric, to the capacitance, C_v, of the same electrode configuration with a vacuum as the dielectric.

$$K = \frac{C_p}{C_v}$$

Implicit in this definition is the condition that the material must extend to infinity in all directions. It is in the determination of these two capacitances that errors may occur.

There are three methods available for such measurements: the guard-electrode method, the micrometer-electrode method, and the wire-connector method. Each of these methods either eliminates or compensates the errors caused by the use of a finite specimen.

Guard-Electrode Method

The guard-electrode method eliminates these errors by placing a guard electrode around one of the measuring electrodes. When the width of this guard electrode is twice the thickness of the specimen, the error in the capacitance measurement is less than −0.2 per cent. Since this error is independent of the dielectric constant of the material, the error in the calculated value of dielectric constant is negligible. This condition holds for gases and liquids, for which rigid electrodes may be provided. For liquids, whose dielectric constants are usually greater than 2, the cell containing the electrodes need not be evacuated, since the dielectric constant of dry air is only 0.053 per cent greater than 1.

Since solid dielectrics cannot be fitted in between rigid electrodes with sufficient exactness, some type of flexible electrode must be provided and the vacuum capacitance calculated from the dimensions of the guarded electrode and the thickness of the specimen. The radius of a circular electrode is nominally increased by half the width of the gap between guarded and guard electrodes. Actually this increase should be less than this amount by a fringing constant, δ, which is a function of the gap width. The error in capacitance, produced when this correction is not applied, amounts to about +0.25 per cent for a specimen thickness of $\frac{1}{16}$ in. and a gap width of 0.02 in., which is about the least that can be obtained with thin flexible electrodes. Because of uncertainties in the formulas for the fringing constant, this error is only reduced by a factor of 4 when the correction is applied. The errors occurring in the measurement of diameter and thickness usually dominate and may amount to 0.5 per cent for a thickness of $\frac{1}{16}$ in., giving a total error in vacuum capacitance of 0.6 per cent. Since a reasonable error in capacitance measurements at a level of 20 $\mu\mu$f is 0.2 per cent, the error in dielectric constant will be 0.8 per cent.

Micrometer-Electrode Method

The micrometer-electrode method uses specimens having thin flexible electrodes extending to the edge of the specimen. The fringing capacitance at the edge of the specimen is nearly eliminated by a substitution type of measurement in which the capacitance of the system with the specimen clamped between the system electrodes is maintained, when the specimen is removed, by bringing the electrodes closer together. When the specimen is the same size as the electrodes, its presence changes slightly the fringing capacitance and produces an error of about $+0.05/t$ per cent, where t is the specimen thickness, or +0.8 per cent for a thickness of $\frac{1}{16}$ in. This source of error can be eliminated by making the radius of the specimen less than that of the system electrodes by the specimen thickness. Since the capacitance calibration of a micrometer-electrode system is usually not as accurate as that of a multiple-plate air capacitor, the error in the determination of dielectric constant by this method may be set at 1.0 per cent for a specimen thickness of $\frac{1}{16}$ in.

Any comparison of these two methods brings in convenience of operation and availability of equipment as well as accuracy of measurement. The guard-electrode method requires the use of a guard-circuit bridge or its equivalent. The application of the guarded and guard electrodes with a narrow gap between is sometimes quite difficult. A micrometer-electrode system is decidedly more complicated than any three-terminal cell. It affords no protection against the effects of a water film formed on the edge of the specimen under conditions of high humidity.

Wire-Connector Method

The total capacitance of a specimen having thin flexible electrodes extending to the edge is measured by a substitution type of measurement in which a fine wire first makes contact with the high electrode and then is lifted a short distance so that the connection error is less than 0.02 $\mu\mu$f, or 0.1 per cent for a capacitance of 20 $\mu\mu$f. Included in the measured capacitance is the fringing capacitance at the edge of the specimen and the capacitance of the high electrode to ground. Formulas for these capacitances are now available, expressed in terms of the dimensions of the specimen and its height above the ground plane. Their indicated accuracy is 7 per cent for edge capacitance and 25 per cent for ground capacitance. The magnitudes of these capacitances are such that the capacitance of the specimen can be obtained to 1.5 per cent and its dielectric constant to 2.0 per cent.

Reference

A more detailed description of the three methods mentioned here is given in a paper with the same title, which will appear in the 1954 *Proceedings* of the American Society for Testing Materials. Exact formulas are given there for all the various corrections, together with the observational data substantiating them. The necessity for using thin flexible electrodes is shown. Even the finest machining and grinding of specimen and electrodes appears to leave an effective air gap at least 0.7 mil thick, which for a specimen thickness of $\frac{1}{16}$ in. will cause an error of −3 per cent. Also with foil electrodes the oil or grease used for adhesion will have a thickness of several tenths mil and will cause a corresponding error. Sprayed or evaporated metal or silver paint should be used instead to reduce this type of error, which becomes very serious with thin films.

* Engineer (Retired), General Radio Co., Cambridge, Mass.

Symposium on Color of Transparent and Translucent Products

Introduction

In the field of appearance problems, there has been relatively little coordination of effort in the measurement of the color of transparent and translucent materials. This is surprising in view of the tremendous dollar volume of commercial materials in this class, running the gamut from glass, paints, plastics, and oils to edible products.

Against this background, ASTM Committee E-12 on Appearance scheduled a symposium at the ASTM Spring Meeting, February 3, 1954, at Washington, D. C., to review the situation. A major objective was to reveal unevenness in the development and use of colorimetric methods in the several industries represented. This goal was successfully achieved and with it was obtained an awareness of problems in the colorimetric field of sufficient potential interest to the participating industries to justify research effort and expenditure, preferably in the academic domain. Ultimately the product of this type of effort should be not only answers to the specific problems presented, but also personnel familiar with and interested in pursuing these broad fields of application of colorimetry.

By George W. Ingle

EDITOR'S NOTE.—Four papers of the symposium appear on the following pages. The last three papers, a summary, and general discussion will appear in the December issue of the ASTM BULLETIN.

The Determination of the Color of Petroleum Products

By H. M. Hancock and J. J. Watt

The authors describe development of methods for determination of color of petroleum products by ASTM Committee D-2 on Petroleum Products, illustrating the difficulties encountered in attempting to revise and standardize poorly conceived methods.

PETROLEUM products possess a wide variety of physical and chemical properties. They range from commercially pure gaseous hydrocarbons, which boil below the freezing point of water, through a large number of nonviscous and viscous liquids, to highly complex asphaltic and waxy solids melting above the boiling point of water, and finally to a relatively pure form of carbon-petroleum coke.

This presentation is limited to the determination of the color of liquid petroleum products and to products that are readily liquefiable for inspection purposes. Also, this paper considers color as determined by transmitted light only. Fortunately for the petroleum technologist, color by reflected light is not considered to be of sufficient significance to warrant formal consideration.

METHODS IN GENERAL USE

Reference to the 1929 Report of ASTM Committee D-2 on Petroleum Products and Lubricants[1] discloses that there were three methods at that time for the determination of the color of petroleum products. They were the Saybolt Chromometer Method for Refined Petroleum Oil (naphthas, kerosines, etc.), the Union Colorimeter Method for Lubricating Oils, and the Union Colorimeter Method for Petrolatum. Actually, there were only two basic methods, since the two Union Colorimeter Methods differed only in the provision for melting the petrolatum prior to the color determination.

The methods had three features in common: they were based on the visual comparison of the petroleum product with glass standards; they had developed through a Topsy-like evolu-

[1] Report of Committee D-2 on Petroleum Products and Lubricants, *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 351 (1929).

H. M. HANCOCK, Manager, Product Control Dept., The Atlantic Refining Co., Philadelphia, Pa., has been associated with the work of Committee D-2 for 30 years. For a number of years he has been chairman of its Research Division IX on Color.

J. J. WATT, Supervisor, Standards Laboratory, Product Control Dept., The Atlantic Refining Co., Philadelphia, Pa., has more than 25 years experience in the petroleum industry, largely in the development and standardization of apparatus and methods for the measurements of the physical properties of petroleum products.

tion; and they were poorly specified with respect to sample containers, optical system, light source, and glass color standards.

Today, 25 years later, what is the status of the color determination methods for petroleum products?

There are still the same two basic methods. The Saybolt Chromometer method[2] is used for "undyed motor and aviation gasoline, jet propulsion fuels, naphthas, and kerosines, and, in addition, petroleum waxes and pharmaceutical white oils." The color of these products varies from "colorless" to pale straw. In general appearance, the current apparatus resembles the earlier models. However, by periodic improvements, the present method is adequately specified with respect to sample containers, optical system, light source, and glass color standards. The indications are that this method will continue to serve the petroleum industry satisfactorily. Obviously, periodic improvements will be made in specification features, and modifications may be made in the terminology to permit ingenious improvements by the apparatus manufacturers. Basically, the Saybolt Chromometer method determines, under prescribed conditions, the adjusted height of a column of oil sample which matches, in color, one of a series of three color standards. The Saybolt method measures approximate chromaticity, since the observer evaluates a combination of hue and saturation, because the chromaticity of petroleum products varies appreciably.

What about the evolution in the color determination of lubricating oil and petrolatum? Today, the present Union Colorimeter method[3] continues to include both a poorly conceived optical system and inadequately specified glass color standards. The light source has been standardized.

In the Union Colorimeter method, the sample, in a specified bottle (4-oz sample bottle), and the color standard are illuminated by standardized artificial daylight consisting of an incandescent lamp of specified color temperature and a filter of selected spectral transmittances. The color of the sample is compared with a series of twelve color standards. The number of the standard which the color of the oil "most nearly" matches is recorded as the color of the sample.

[2] Tentative Method of Test for Saybolt Color of Refined Petroleum Products (Saybolt Chromometer Method) (D 156 – 53 T), 1953 Supplement to Book of ASTM Standards, Part 5, p. 21.

[3] Tentative Method of Test for Color of Lubricating Oil and Petrolatum by Means of ASTM Union Colorimeter (D 155 – 45 T), 1952 Book of ASTM Standards, Part 5, p. 86.

Before presenting the current plans of Research Division IX on Color of ASTM Committee D-2 on Petroleum Products and Lubricants for correcting the shortcomings of the Union Colorimeter, a review of the past efforts and failures might be of interest to other organizations confronted with similar problems.

The continuing difficulty has been the justification for creating an acceptable method. Color is not a basically significant property of a large majority of petroleum products. Generally, it has been specified either for identification purposes or as a criterion of contamination. Even where there is some relationship between the color and the stability or utility of the product, many direct methods have been developed which measure the significant property more accurately. Another factor has been the increasing practice of marketing petroleum products that are dyed or contain colored additives. Under these conditions, it has been difficult to develop the proper response required for the creation and adoption of an acceptable method.

Of the many alternate methods developed for color measurement of petroleum products, the Tag-Robinson Colorimeter and the Lovibond Tintometer probably have found the most acceptance. In this country, they have been used mainly for process control purposes. They have not been standardized or adopted by ASTM.

The Tag-Robinson Colorimeter measures the color of lubricating oils in one dimension. It has three glass color standards which are compared with an adjustable layer of the sample. Oil samples that appear to be similar when observed in a fixed layer—for example, in oil sample bottles—may have appreciably different appearances in the Tag-Robinson Colorimeter.

The Lovibond Tintometer method is applicable to all petroleum products for which the Saybolt Chromometer and the Union Colorimeter are used. It has both a three-dimensional and a single-dimensional color scale. The former employs three series of additive glass standards. A complete set of standards consists of 165 red, yellow, and blue glasses. The single-dimensional scale employing a series of amber glass standards is no longer in general use. The Lovibond scales are reasonably satisfactory for measuring the color of petroleum products.

The Union Colorimeter Method

Historically, the Union Colorimeter was developed for the determination of the color of lubricating oils made from Pennsylvania crude oil. These oils possess appreciably higher saturation and greater brilliance than many of the products for which the instrument is now used. Therefore, many laboratories have experienced extreme difficulty in matching the color of their samples with a series of glass color standards that were based on the color of Pennsylvania lubricating oils. This shortcoming was recognized but was considered secondary to the solution of the problem of obtaining a source of supply of adequately specified glass color standards.

Unfortunately, the Union Colorimeter was a patented instrument. The sole manufacturing rights had been granted to one company, and the original set of master glass color standards were in the possession of that com-

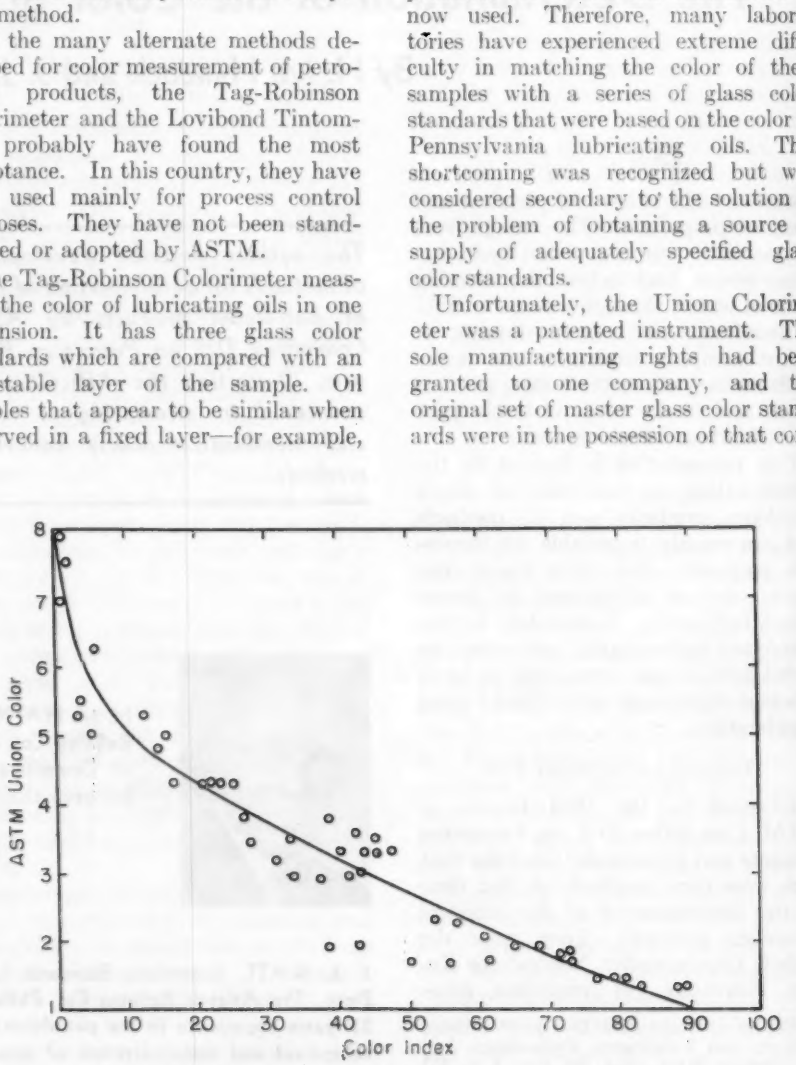


Fig. 1.—Correlation of Photoelectric Color Index with ASTM Union Color.

pany. Research Division IX obtained these standards and had the transmission of the twelve glasses measured.[4] This was the first of a long series of services that the National Bureau of Standards has performed for Research Division IX. From this information, the chromaticity coordinates and the luminous transmittances were calculated by means of the CIE standard observer C. These measurements and calculations have been the basis of all the work that has been performed on the Union Colorimeter glass color standards.

The next step was to have a glass manufacturer agree to make the series of color standards which duplicated the spectral characteristics of the master standards. The orginal color standards had been made by an English manufacturer, and unfortunately, this company would not accept the responsibility of supplying adequately specified color glasses.

The Division next attempted to interest an American manufacturer in supplying color standards. This company requested an advance of $5000 to defray the cost of the necessary research work. In 1930, $5000 was a large sum of money to standardize a poorly conceived method of measuring an unessential property of petroleum products, and the funds were not forthcoming.

The problem was then presented to a German glass manufacturer who consented to manufacture the color standards. This company agreed to duplicate the glasses within a tolerance of ±0.006 unit for the chromaticity coordinates and a somewhat less realistic specification of ±10 per cent for luminous transmittance. Ultimately, the Research Division was supplied with a set of standards. Five of the duplicates were found to comply with the prescribed tolerances while the remainder did not deviate markedly. On the second attempt, three additional glasses were found to be satisfactory. The manufacturer was correcting the deficiencies of the four remaining unacceptable standards when World War II broke out.

Photoelectric Methods

The Division had followed the application of photoelectric methods for the color determination of petroleum products. These methods had found some acceptance in the industry for process control, and the lack of supply of even reasonably uniform Union Colorimeter color standards served as an incentive to investigate photoelectric methods more thoroughly. In 1933, Story and Kalichevsky (1)[5] proposed the use of a photoelectric transmission method that measured brilliance rather than hue. Research Division IX studied the photoelectric colorimeter and method reported by Diller, DeGray, and Wilson in 1942 (2), and by Diller, Dean, DeGray, and Wilson in 1943 (3).

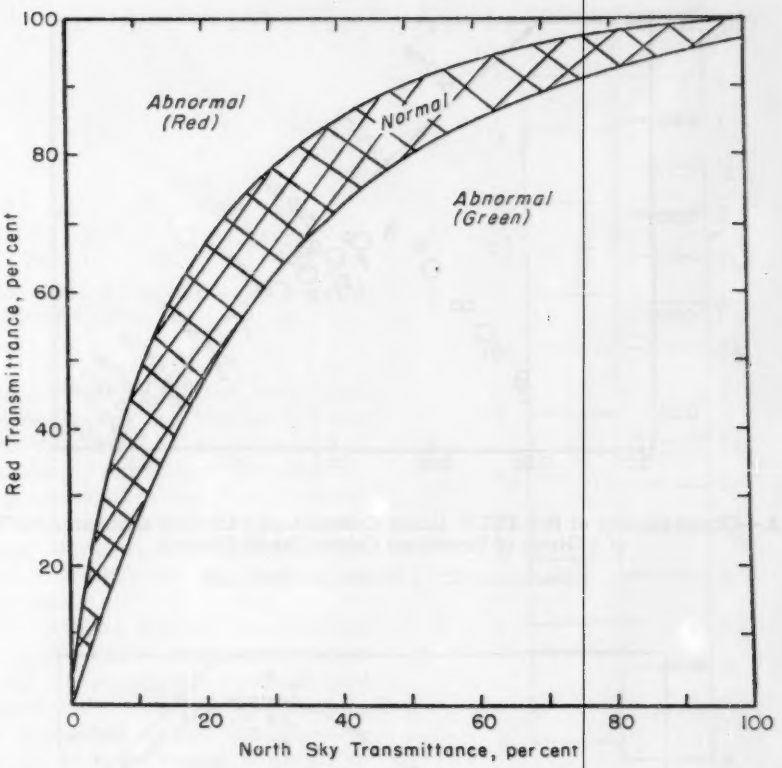


Fig. 2.—Region of Normal Color.

Two years of intensive cooperative work resulted in the development of a Proposed Method of Test for Color of Lubricating Oil by Means of Photoelectric Colorimeter published as information in 1942.[6] Basically, the method consisted of measuring the transmittance of the petroleum product relative to distilled water with light from a wide range "north sky" color filter. A "red" filter transmission reading indicated the approximate hue of the test sample. The method was applicable to color determination of gasolines and kerosines by the use of a "violet" filter. It was found necessary to develop response specifications for the calibration of the colorimeter used in the cooperative work. The standards used for this purpose were specified solutions of ferric chloride, cobaltous chloride, and a mixture of the two.

The publication of the method did not generate sufficient interest within the membership of Committee D-2 to warrant the Division's recommending its acceptance as an ASTM Tentative Method.

In 1944, the Division reinitiated a program of work on the development of a photoelectric color method. The previously published procedure had a number of deficiencies. As a result of an even more elaborate program of cooperative work, the ASTM published in 1947 a Proposed Method for Determination of Color Index of Petroleum Products by Photoelectric Colorimeter.[7]

The newer method was a distinct improvement over its predecessor. The major advantages were: the apparatus was specified so that several available commercial instruments complied with the requirements; (2) CIE daylight, blue, and amber filters were substituted for the north sky, violet, and red filters; (3) colored glass standards replaced the inorganic standard solutions; (4) rectangular cells with parallel walls were substituted for the tube-type cells; (5) narrow cells were specified for use with dark-colored samples rather than the previous practice of predilution; (6) a parallel beam of light was substituted for the converging beam; and (7) a means was provided for correlating photoelectric color index with ASTM Union Colorimeter values.

[4] Report of National Bureau of Standards Test No. 57968 issued December 18, 1929, to ASTM Committee on Petroleum Products and Lubricants.

[5] The boldface numbers in parentheses refer to the list of references appended to this paper.

[6] Report of Committee D-2 on Petroleum Products and Lubricants, Appendix II, *Proceedings*, Am. Soc. Testing Mats., Vol. 42, p. 317 (1942).

[7] Report of Committee D-2 on Petroleum Products and Lubricants, Appendix IV, *Proceedings*, Am. Soc. Testing Mats., Vol. 47, p. 307 (1947).

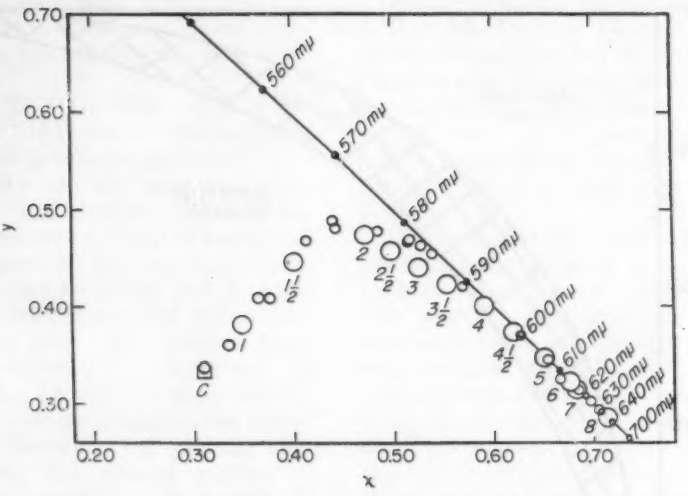


Fig. 3.—Chromaticities of the ASTM Union Colors (Large Circles) Compared to Those of a Group of Petroleum Colors (Small Circles).

Measured by Diller, DeGray, and Wilson.(2)

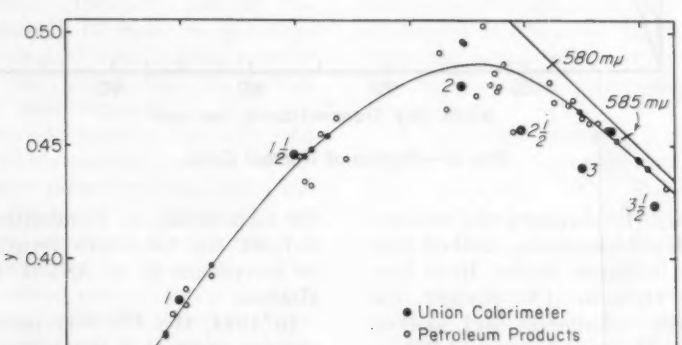


Fig. 4.—Comparison of the Chromaticities of the Union Colorimeter Standards with Those of Representative Petroleum Products Collected by Research Division IX.

The basic disadvantage of the new method was that the use of the CIE filter had improved the precision of the colorimeter at the expense of sensitivity.

Additional cooperative work included the reversion to the use of the original "north sky," "red," and "violet" filters, the control of temperature of the sample during measurement, and the use of Lumetron model 402E,[8] exclusively.

In 1949, Lykken (4) published a comprehensive discussion and summary of the cooperative work that had been performed in the development of the application of photoelectric colorimetry to petroleum products.

The Proposed Method for Determination of Color Index of Petroleum Products by Photoelectric Colorimeter[9] was published in 1949. This method has been available to the petroleum industry for four years. In many respects it is superior to the Union Colorimeter it was developed to replace. However, it, too, has never found sufficient acceptance with Committee D-2 to warrant its being suggested as an ASTM Tentative either as a replacement or as an alternate to the Union Colorimeter method.

Why has it been difficult to obtain adoption of a photoelectric method for the color determination of petroleum products? There are several reasons. The first is inertia. Second, as shown in Fig. 1, there is questionable correlation between photoelectric Color Index and Union Color numbers. As an extreme example, in the region of a Color Index of 40, the Union Color numbers may vary by as much as 2 numbers. Third, the Color Index Method lacks sensitivity in distinguishing between oils darker than 5 ASTM Union Color. Fourth, a significant percentage of petroleum products exhibit "abnormal" photoelectric measurement characteristics. Referring to Fig. 2, an abnormal sample is one that does not fall within the arbitrary band of north sky - red transmittances. If this band were broadened to reduce the percentage of "abnormal" samples, the correlation of photoelectric Color Index and ASTM Union Color would be influenced adversely. Fifth, a photoelectric colorimeter requires more skillful handling than does the Union Colorimeter.

The Relocated and Respaced Scale

In 1948, the Division decided to resume the work of placing the Union Colorimeter method upon a more satisfactory basis. An American manufacturer agreed to cooperate in the creation of acceptable glass color standards. The initial set of glasses submitted to the Division was generally satisfactory except that the lighter-colored standards were "more yellow" than the master standards.

Before requesting the manufacturer to adjust the spectral characteristics of the submitted glasses, Research Division IX initiated another research program. Work by Diller, DeGray, and Wilson (2), shown in Fig. 3, indicated that the chromaticity of lighter-colored petroleum products did not match the chromaticity of the master standards. Later work performed by Judd, Plaza, and Belknap (5), shown in Fig. 4, corroborated the data of Diller, DeGray, and Wilson.

Since this finding was considered to be of significance, the Division decided to revise the chromaticity of the lighter-colored Union standards—specifically, those from the 1½ to the 4 Color Number. At the same time, another deficiency of the master standards was corrected—the nonuniformity of the chromaticity spacing. It was also decided to add 0, ½, 5½, 6½, and 7½ Color Numbers to the original series of twelve standards.

Judd, Plaza, and Belknap derived and recommended a relocation and respacing of the Union color scale which would appear uniform under the conditions of viewing specified in the Union Colorimeter method (5). Figure 5 compares the recommended spacing with the present spacing of the Union color

[8] Photovolt Corp., New York, N. Y.

[9] Report of Committee D-2 on Petroleum Products and Lubricants, Appendix V, *Proceedings*, Am. Soc. Testing Mats., Vol. 49, p. 349 (1949).

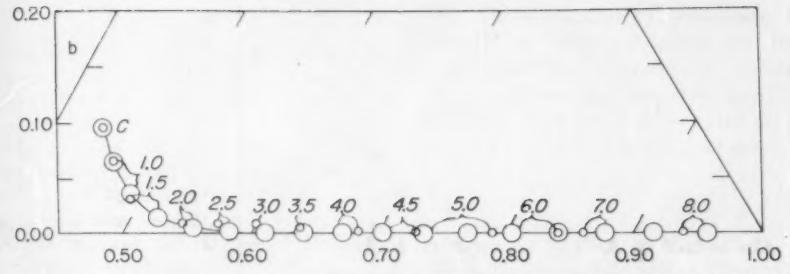


Fig. 5.—Recommended Spacing of the Union Color Scale (Large Circles) Compared with the Present Union Scale (Small Circles).

scale on the UCS chromaticity diagram. Table I compares the present and proposed specifications for the glass color standards. This recommended uniform spacing assures uniform visual differences throughout the entire Union scale. The spacing between the standards increases as the color increases to compensate for the fixed light source specified in the Union method.

Figure 6 illustrates the comparison between recommended uniformly spaced scale and the present scale. Is there any question as to the relative merits of the two scales? Admittedly, the adoption of the recommended scale would require a shifting in the present conception of some ASTM Union Color Numbers. The word "conception" is used advisedly. Research Division IX's cooperative data indicate that the suggested shifts are no greater than many of the deviations in color readings that were obtained on identical samples in the laboratories of the members of the Division. For example, the data indicate variations between laboratories up to 0.5 Number for oils between 3 and 7 ASTM Color Numbers. Variations in the order of 0.5 Number were found to exist between the Number 7 Color glasses which were being used as official standards by four major petroleum refining companies having Division representation. Obviously, the variations existing throughout all petroleum inspection laboratories are much more pronounced.

The Division adopted specifications for the color standards which were based on the recommended relocated and respaced scale. The new specifications were submitted to the manufacturer who had prepared the set of glasses to match the master standards. Unfortunately, this manufacturer was no longer interested in continuing work on the project.

In 1951, Hellige, Inc., agreed to manufacture a set of standards complying with the new specifications. Hellige also agreed to have the National Bureau of Standards retain this set of glasses. The Division planned to recommend that these glasses be adopted as new master standards at the time ASTM adopted a revision of the present method.

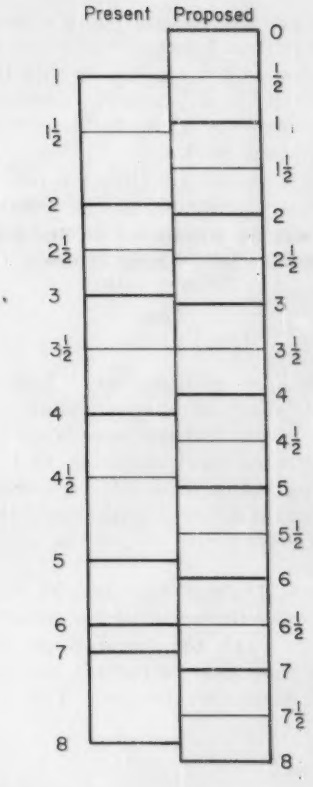


Fig. 6.—Comparison of the Proposed ASTM Uniformly Spaced Color Scale with Present Union Scale.

The set of glasses manufactured by Hellige, Inc., approximated the color characteristics of the original master standards. From the analysis of these glasses, the National Bureau of Standards recommended how glasses complying with the new specifications could be made (6).

TABLE I.—PRESENT AND PROPOSED SPECIFICATIONS FOR GLASS COLOR STANDARDS.

ASTM Color Numbers	Present ASTM Union Color Scale							Proposed Uniformly Spaced ASTM Color Scale			
	Lovibond Analysis Specifications			Analysis of Master Color Standards							
				Uniform Chromaticity Scale Coordinates			Luminous Transmittance	Uniform Chromaticity Scale Coordinates[a]			Luminous Transmittance
	Red 200 Series	Yellow 510 Series	Blue 1180 Series	Red (r)	Green (g)	Blue (b)	*Tw*	Red (r)	Green (g)	Blue (b)	*Tw*
(0)	...	...	...	...	...	...	...	0.439	0.465	0.096	0.92 ± 0.03
½	...	...	...	...	...	...	...	0.462	0.473	0.065	0.86 ± 0.03
1	0.12	2.4	...	0.462	0.476	0.062	0.750	0.489	0.475	0.036	0.77 ± 0.03
1½	0.60	8.0	...	0.491	0.477	0.032	0.654	0.521	0.464	0.015	0.67 ± 0.03
(2	2.5	26.0	...	0.542	0.448	0.010	0.443	0.552	0.442	0.006	0.55 ± 0.03
2½	4.6	27.0	...	0.570	0.421	0.009	0.365	0.582	0.416	0.002	0.44 ± 0.02
3	6.9	32.0	...	0.600	0.393	0.007	0.287	0.611	0.388	0.001	0.31 ± 0.02
3½	9.4	45.0	...	0.636	0.360	0.004	0.211	0.640	0.359	0.001	0.22 ± 0.02
4	14.0	50.0	0.55	0.683	0.315	0.002	0.096	0.671	0.328	0.001	0.152 ± 0.011
4½	21.0	56.0	0.55	0.729	0.270	0.001	0.065	0.703	0.296	0.001	0.109 ± 0.008
5	35.0	93.0	...	0.789	0.210	0.001	0.036	0.736	0.264	0.000	0.081 ± 0.006
(5½	...	...	...	...	...	...	...	0.770	0.230	0.000	0.058 ± 0.005
6	60.0	60.0	0.55	0.841	0.159	0.000	0.017	0.805	0.195	0.000	0.040 ± 0.004
(6½	...	...	...	...	...	...	...	0.841	0.159	0.000	0.026 ± 0.003
7	60.0	106.0	1.8	0.860	0.140	0.000	0.0066	0.877	0.123	0.000	0.016 ± 0.002
(7½	...	...	...	...	...	...	...	0.915	0.085	0.000	0.0081 ± 0.0008
8	166.0	64.0	...	0.938	0.062	0.000	0.0020	0.956	0.044	0.000	0.0025 ± 0.0003

[a] Tolerances on the chromaticity coordinates r, g, and b are ±0.006.

Subsequently, Hellige manufactured and submitted for analysis a set of glasses prepared in accordance with the recommended specifications. Fourteen of the 16 glasses complied with specification requirements (13).

At the present time, Hellige is manufacturing replacements for the remaining two glasses, and it is expected that they will be submitted to Division IX for analysis in the near future.

The Future

Where do we go from here? Assuming that a set of master standards, complying with the new specifications, is forthcoming, and assuming that a continuing source of supply of acceptable glasses is assured, what should the Division recommend to ASTM Committee D-2?

Research Division IX plans to prepare a complete redraft of the present method in which the specifications for the new glass color standards will be the only sacrosanct feature. The detailed apparatus requirements will be limited to those essential to insure acceptable precision and accuracy. The Division hopes to complete this work in time to submit it to ASTM Committee D-2 in 1955.

Acknowledgment:

On behalf of ASTM Committee D-2, the authors express their appreciation to the National Bureau of Standards, and to D. B. Judd and his associates in particular, for their sustained cooperation in the work of Research Division IX on Color. This assistance has made it possible for the Division to make some progress in its attempt to place the color determination of petroleum products upon a firmer foundation.

The authors also appreciate the cooperation of apparatus and glass manufacturers who have contributed to the work of the Division down through the years.

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A Color Space for Color Grading Purposes

By George W. Ingle

Grading of the yellowness of many transparent materials is an important measure of quality. To overcome many inaccuracies and limitations of existing methods, a technique is proposed which applies recent data concerned with perceptible color differences.

A problem of some importance in the oil, varnish, naval stores, plastics, and other fields is the measurement of yellowness. By yellowness is meant the degree of deviation from the ideal colorless state to a colored state showing some shade of the yellow hue. This paper is concerned primarily with transparent materials, but the method is general enough to be adapted to translucent and opaque materials.

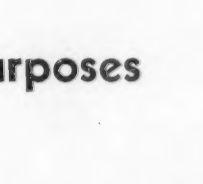
The economic value of this problem is real. It has been estimated that the dollar value of business in uncolored polystyrene molding powder, for example, which is affected by variations in yellowness, is in the order of two million dollars per year. In this case the yellowness involved is low in magnitude compared with that of other materials such as those mentioned above.

It is not uncommon to obtain an empirical measure of yellowness, as the relative absorption of blue, from the spectral transmittance curve for a given thickness of polystyrene plastic, generally about 0.150 in. This index for yellowness may be computed by subtracting the values of transmittance at 420 and 500 mμ from twice the value at 700 mμ. By this basis it will be found that competitive high quality materials average 2.5. Material only one unit more yellow than this will be at a decided competitive disadvantage.

This index of yellowness is only one of many found in use in several industries. Many of these methods are developed from those originally used in the paper industry. Perhaps the most thoroughgoing evaluation of the measurement of yellowness in terms of single numbers has been made by Osborn and Kenyon[1] in the case of certain terpene hydrocarbons. Their conclusions sum up the situation very accurately:

1. So long as the locus of the points representing the colors of the members of

[1] R. H. Osborn and W. C. Kenyon, "A General Method of Color Grading," *Industrial and Engineering Chemistry*, Analytical Edition, Vol. 18, Sept. 15, 1946, pp. 523–530.



GEORGE W. INGLE, Polystyrene Section Leader, Monsanto Chemical Co., Plastics Div., Springfield, Mass., is in charge of color research on all the company's plastics materials. He has been engaged in color research since 1941.

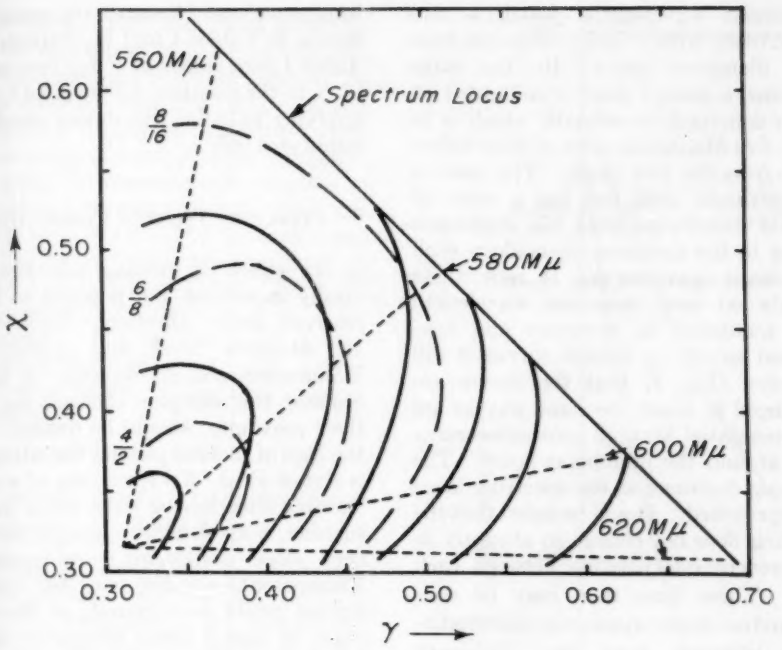


Fig. 1.—Yellow Orange Sector of CIE Chromaticity Diagram Showing Loci of (5×) Perceptible Chromaticity Differences from Origin; Renotated Munsell Chroma Contours Included for Reference.

a series of samples of any one material is a continuous line in the CIE chromaticity-plane, the definition of standards is relatively simple. All that is necessary is to select arbitrary values that are spaced at visually equal distances along this locus.

2. The major difficulty with this approach is that it does not compensate directly for differences in luminance nor is it particularly helpful if the point for the color of the sample being measured is not on the given locus. No provision can be made by relating these "off-locus" colors to the standard colors.

The purpose of this paper is to present a general method for measuring yellowness which attempts to overcome these two limitations. It attempts to describe, in terms of units of perceptible color difference, the magnitude of the color difference between the colorless ideal and the yellowness of any particular sample, regardless of its particular shade of yellow, and with due allowance for its luminance. In other words, this technique aims to define the scalar value of a vector in color space. This vector is drawn from the point of maximum luminance and zero chromaticity (representing the ideal) to the point of somewhat lower luminance and specific chromaticity representing the sample in question.

Use of the MacAdam Equation for Color Difference

The approach used here is an application of the simplified equation for color difference derived from that of MacAdam and previously reported by the author.[2] This simplified equation consists of four terms:

$$\Delta S^2 = g_{11}\Delta x^2 + 2g_{12}\Delta x\Delta y + g_{22}\Delta y^2 + 0.90 \times 10^4(\Delta Y/Y)^2$$

In this equation, ΔS is the root mean square deviation of color matching, which is an effective unit of perceptible color difference, here called "MacAdam units." The g values are the MacAdam coefficients determined for any reference color by graphical interpolation from its known values of x and y chromaticity coordinates.[3] Y is CIE luminance. The quantities Δx, Δy, and ΔY refer to differences in these values between the reference color and any other color, both of which are specified in terms of Y, x, and y.

The first three terms in the equation are concerned solely with chromaticity and the fourth is concerned solely with luminance. For this reason, the two components can be considered separately, and subsequently recombined to provide a single number designating a total color difference.

In using this equation, graphical means have been found most convenient. The luminance axis, designated Y in CIE nomenclature, is divided into increments each equivalent to five MacAdam units of color difference. These fivefold magnitudes were chosen somewhat arbitrarily to minimize computation without introducing important inaccuracies due to the changes in the values of the g constants with chromaticity. Tenfold magnitudes would have halved the amount of calculation involved but at the same time would have introduced greater unreliability.

The fivefold units are computed by beginning from the maximal value of Y of the material in question in the form in which it is normally measured. The initial point could be unity with equal convenience. For polystyrene, for example, the maximal value of Y will be on the order of 0.900 for an injection-molded thickness of 0.150 in.; for acrylic plastic the value will be nearer 0.920. Using the luminance fraction of the equation for color difference, a lower value of luminance representing a color difference of five MacAdam units is computed from this point. Another lower value of luminance is computed which is in turn five MacAdam units from the second. This process is computed to divide the luminance axis into these increments over the total

TABLE I.—LOCI OF (5X) PERCEPTIBLE DIFFERENCES ALONG LUMINANCE (Y) AXIS, FOR TWO CONDITIONS OF VIEWING.

Number of (5×) Perceptible Differences	Values of Luminance (Y)	
	Samples Continuous $K = 0.90 \times 10^4$	Samples Separated $K = 0.09 \times 10^4$
0	0.9050	0.9050
1	0.8573	0.7540
2	0.8121	0.6280
3	0.7695	0.5230
4	0.7289	0.4359
5	0.6905	0.3634
6	0.6540	0.3020
7	0.6194	0.2516
8	0.5867	0.2097
9	0.5557	0.1747
10	0.5264	0.1456
11	0.4986	0.1214
12	0.4723	0.1012
13	0.4473	0.0843
14	0.4237	0.0702
15	0.4013	0.0585
16	0.3801	...
17	0.3600	...
18	0.3410	...
19	0.3230	...
20	0.3059	...
21	0.2898	...
22	0.2745	...
23	0.2600	...
24	0.2463	...
25	0.2333	...
26	0.2210	...
27	0.2094	...
28	0.1984	...
29	0.1879	...
30	0.1780	...
31	0.1686	...
32	0.1597	...
33	0.1513	...

[2] G. W. Ingle and L. Rudick, "Comparison of the MacAdam and the Adams-Nickerson Indexes of Color Difference," *Journal*, Optical Soc. Am., Vol. 43, No. 6, June, 1952, pp. 501–504.

[3] H. A. Robinson, "The Evaluation of Colorimetric Tristimulus Values by Means of a New Centroid Value," *Journal*, Optical Soc. Am., Vol. 36, No. 5, June, 1946, pp. 270–277.

range of luminance normally encountered for the material in question.

A similar process is used to scale the chromaticity dimensions. First, limiting dominant wavelengths for the shades of yellow normally found in the material in question are determined. For polystyrene these limits are approximately 560 and 580 mμ. For nitrocellulose the upper limit is nearer 620 mμ. In practice one establishes the linear equation defining each of these dominant wavelengths plus those at selected intermediate values to obtain a group of wavelengths such as 560, 580, 600, and 620 mμ. The equations used for each of these four wavelengths are:

$$\text{at } 560 \text{ m}\mu \quad y = 4.890x - 1.200$$
$$\text{at } 580 \text{ m}\mu \quad y = 0.841x + 0.0555$$
$$\text{at } 600 \text{ m}\mu \quad y = 0.1777x + 0.2612$$
$$\text{at } 620 \text{ m}\mu \quad y = 0.0210x + 0.3228$$

With the linear equation for each of these dominant wavelengths is combined the equation for color difference involving only chromaticity. A point is computed on the line of each of these dominant wavelengths which is five MacAdam units of color difference from the illuminant point. By the same process, a second point is computed on each dominant wavelength which is in turn five MacAdam units of color difference from the first point. This process is continued until one has a series of points distributed from the illuminant point to the spectrum locus along each dominant wavelength. If now these points on each dominant wavelength are numbered in sequence and connected serially by smooth curves, it will be seen (Fig. 1) that the curves are arranged in much the same way as are the renotated Munsell constant-chroma loci around the illuminant point. The spacing decreases as the spectrum locus is approached. It will be noted that the spacing does not change so abruptly as to prevent interpolating between each line. These lines then may be considered as lines of equal color (chromaticity) difference from the illuminant point. The values computed for the luminance and chromaticity scales are shown in Tables I and II, respectively. Table I lists values of Y for two values of K in the equation $\Delta S^2 = K(\Delta Y/Y)^2$, applying to color differences involving luminance only.

TABLE II.—LOCI OF (5×) PERCEPTIBLE DIFFERENCES ALONG LINES OF CONSTANT DOMINANT WAVELENGTH (mμ).

Number of (5×) Perceptible Differences	560 mμ		580 mμ		600 mμ		620 mμ	
	x	y	x	y	x	y	x	y
0	0.3101	0.3163	0.3101	0.3163	0.3101	0.3163	0.3101	0.3163
1	0.3118	0.3245	0.3169	0.3220	0.3154	0.3172	0.3148	0.3162
2	0.3135	0.3327	0.3238	0.3278	0.3207	0.3181	0.3195	0.3161
3	0.3152	0.3410	0.3309	0.3338	0.3260	0.3191	0.3243	0.3160
4	0.3171	0.3502	0.3387	0.3404	0.3315	0.3201	0.3292	0.3159
5	0.3191	0.3599	0.3467	0.3472	0.3372	0.3211	0.3342	0.3158
6	0.3214	0.3710	0.3554	0.3545	0.3432	0.3222	0.3394	0.3157
7	0.3239	0.3831	0.3644	0.3621	0.3495	0.3233	0.3447	0.3156
8	0.3266	0.3962	0.3743	0.3704	0.3560	0.3245	0.3502	0.3155
9	0.3299	0.4121	0.3847	0.3791	0.3629	0.3257	0.3559	0.3154
10	0.3335	0.4295	0.3956	0.3882	0.3702	0.3270	0.3619	0.3153
11	0.3371	0.4473	0.4062	0.3972	0.3778	0.3283	0.3682	0.3152
12	0.3411	0.4668	0.4166	0.4059	0.3857	0.3297	0.3747	0.3151
13	0.3451	0.4864	0.4268	0.4145	0.3938	0.3311	0.3814	0.3150
14	0.3492	0.5064	0.4363	0.4225	0.4022	0.3326	0.3883	0.3149
15	0.3534	0.5269	0.4453	0.4301	0.4110	0.3342	0.3954	0.3148
16	0.3578	0.5483	0.4539	0.4373	0.4200	0.3358	0.4027	0.3146
17	0.3625	0.5712	0.4619	0.4441	0.4293	0.3374	0.4101	0.3144
18	0.3670	0.5934	0.4697	0.4506	0.4389	0.3391	0.4177	0.3142
19	0.3719	0.6174	0.4772	0.4569	0.4486	0.3408	0.4255	0.3140
20	...	...	0.4846	0.4631	0.4586	0.3426	0.4335	0.3138
21	...	...	0.4917	0.4691	0.4688	0.3444	0.4416	0.3136
22	...	...	0.4987	0.4750	0.4792	0.3462	0.4499	0.3134
23	...	...	0.5054	0.4807	0.4895	0.3481	0.4583	0.3132
24	...	...	0.5120	0.4863	0.5006	0.3500	0.4669	0.3130
25	...	...	...	...	0.5116	0.3520	0.475.	0.3128
26	...	...	...	...	0.5229	0.3540	0.4846	0.3126
27	...	...	...	...	0.5334	0.3560	0.4937	0.3124
28	...	...	...	...	0.5449	0.3580	0.5030	0.3122
29	...	...	...	...	0.5567	0.3601	0.5124	0.3120
30	...	...	...	...	0.5685	0.3622	0.5220	0.3118
31	...	...	...	...	0.5803	0.3643	0.5318	0.3116
32	...	...	...	...	0.5917	0.3663	0.5420	0.3114
33	...	...	...	...	0.6031	0.3683	0.5524	0.3112
34	...	...	...	...	0.6145	0.3703	0.5630	0.3110
35	...	...	...	...	0.6256	0.3723	0.5739	0.3108
36	...	...	...	...	0.6367	0.3743	0.5851	0.3106
37	...	...	...	...	...	...	0.5966	0.3104
38	...	...	...	...	...	...	0.6081	0.3102
39	...	...	...	...	...	...	0.6199	0.3100
40	...	...	...	...	...	...	0.6317	0.3098
41	...	...	...	...	...	...	0.6438	0.3095
42	...	...	...	...	...	...	0.6559	0.3092
43	...	...	...	...	...	...	0.6680	0.3089
44	...	...	...	...	...	...	0.6801	0.3086
45	...	...	...	...	...	...	0.6922	0.3083

Effect of Viewing Conditions

The effect of viewing conditions is vitally important, but it seems to have received little attention. Aside from an adequate level and quality of illumination and specification of background, the samples themselves, and their proximity, should be defined. In the case of molded plastics the situation is almost ideal—flat specimens of widely variable sizes having polished or matte surfaces, with straight edges permitting very close positioning, are common. Transparent plastics can be viewed against white backgrounds or through edges of closely fitted specimens along their longest dimensions, of the order of 6 in. or more.

Transparent liquids present a considerably more difficult problem because they must be viewed in some sort of container, generally a glass tube or bottle. Whether viewed longitudinally or radially, it is impossible to view samples in close contact. What is worse, radial views must include some light transmitted by the container itself. If the container is round in cross-section, the observer is confused by the varying thicknesses of the sample through which light is transmitted.

The importance of sample separation has been sketched by MacAdam.[4] Under practical conditions of color-print examination, for example, the relative effectiveness of chromatic difference compared with luminance difference is fifteen times greater than in a 2-deg colorimeter field and one hundred times greater than in visual acuity tests. Under these same practical conditions, MacAdam's data for the root-mean-square deviation of color matching are adequate to describe chromaticity difference.[5]

For the purposes of this paper, this effect is handled by the value of the constant in the fourth (luminance) term in the color difference equation. For the case of plastics where closely fitting samples are the rule in such comparison, the value 0.90×10^4 has been found

[4] D. L. MacAdam, "Color Discrimination and the Influence of Color Contrast on Visual Activity," *Revue d'Optique*, Vol. 28, No. 3, pp. 161–173 (1949).

[5] D. L. MacAdam, "Specification of Small Chromaticity Differences," *Journal*, Optical Soc. Am., Vol. 33, No. 1, January, 1943, pp. 18–26.

satisfactory. For other cases involving greater separation of samples—liquids, for instance—lower values should be more effective. In Fig. 2 are shown perceptible luminance differences over a wide range of luminance for two cases: (1) using the constant 0.90×10^4 and (2) using a constant of one tenth this value, or 0.09×10^4. In each case, the luminance values are computed to be five MacAdam units apart ($\Delta S^2 = 25$ root-mean-square deviations of color matching). For specific cases, it may be found that values of this constant other than either of these may be more useful.

Use of the Color Space for Color Grading

To use this color space for color grading in practice, only the CIE specifications Y, x, and y are needed, for both the colorless ideal and the sample in question. The two corresponding points are located along the divided luminance axis and also on the scaled chromaticity plot. The difference in color difference units may be read directly from each, with interpolation, if necessary. Referring to the equation for color difference, it will be seen that if the square of the luminance fraction is added to the square of the chromaticity fraction the total color difference is the square root of the resulting sum. This number then will be a single number designation of the difference in color between the sample in question and the optimal colorless ideal.

It is recognized that obtaining the CIE specifications Y, x, and y is not always convenient or possible. Tristimulus colorimeters, though not of the highest accuracy, provide this kind of information most readily, and generally with excellent precision and sufficient accuracy. A recording spectrophotometer without integrator will readily provide a spectral transmittance or reflectance curve which for serial measurements in the simpler cases, at least, will provide X, Y, Z tristimulus values by the direct approximation method described by Robinson[3] from which are obtained the chromaticity coordinates x and y by the usual procedure.

If one has only limited access to such instrumentation but is faced with the task of grading many samples of the same type for an extended period of time, selected samples illustrative of the whole range could be measured for subsequent use as standards.

In this connection it is interesting to compare the results of this technique with those reported by Osborn[1] for terpene hydrocarbons. Interpolating chromaticity, C, and the somewhat irregular luminance, L, values for the four grades indicated and computing color differences by the present procedure using Fig. 2, for both close and separated positioning of the samples, the data given below Fig. 2 were obtained.

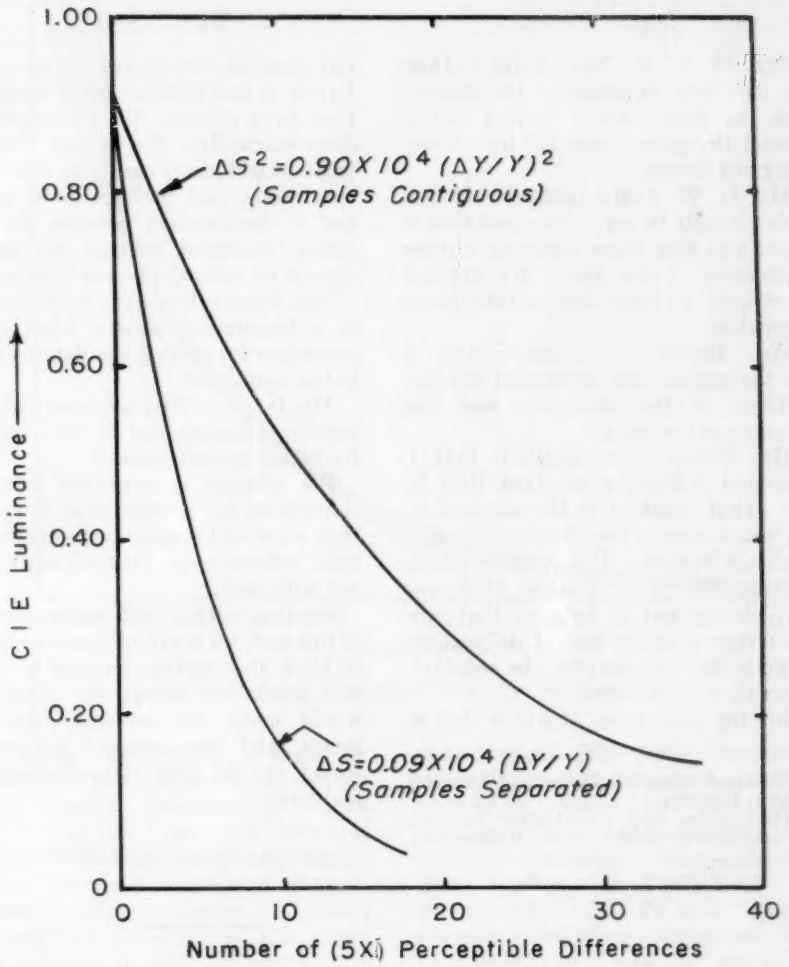


Fig. 2.—(5×) Perceptible Luminance Differences at Various Luminance Levels as Affected by Proximity of Samples.

Grade	Values for Close Positioning				Values for Separated Positioning			
	L_c	C_c	$(L^2+C^2)_c^{1/2}$	ΔS	L_s	C_s	$(L^2+C^2)_s^{1/2}$	Δs
0...	0	0	0	...	0	0	0	0
1...	5	6	7.8	7.8	1.3	6	6.2	6.2
2...	12.5	9	15.4	7.6	3.8	9	9.8	3.6
3...	20	12	23.3	7.5	6.3	12	13.6	3.8
4...	26	14	29.6	6.3	7.5	14	15.9	2.3

It is evident that the data for closer positioning of the samples obtain a more reasonable spacing for the Osborn standards, in which chromaticity, but not luminance, was used originally to obtain acceptable spacing of standards.

No extended evaluation of the utility of this measurement has been made so far. It is hoped that those interested in this problem in various industries will have an opportunity to determine its real effectiveness, particularly for existing sets of material standards.

Acknowledgment:

The generous contribution of Carl Baumann of the Statistical Quality Control Group of the Monsanto Chemical Co., Plastics Division, in making the bulk of the calculations required in this work, is gratefully appreciated.

DISCUSSION

MR. W. E. K. MIDDLETON.[1]—Does this lend itself to projective transformation, so that evenly spaced colors around the given color fall into something like circles?

MR. G. W. INGLE (*author*).—It is a little bit early to say. I suspect that it might and that there might be further application of this idea. We will not know until we have done a little more calculation.

MR. DEANE B. JUDD.[2]—May I ask the author how he related the importance of the chromatic and the luminous components?

MR. INGLE.—The equation that I presented included a constant, 0.90×10^4. That constant is the measure of the importance of the chromaticity and luminous fraction. For our case, which is concerned with plastics that are conveniently put in form so that one can obtain a sharp line of delineation between the two samples, the constant seems to be quite right.

But for such cases in which that is not possible—let us say in comparing liquids in test tubes or other containers that have corners—that constant may drop markedly. We believe that the value might drop easily to one tenth that value, and perhaps lower, as the line of demarcation between the samples is broadened, so that the samples cannot be viewed in close contact.

MR. SIDNEY NEWHALL.[3]—In the case of a translucent plastic, what is the procedure for getting the data to apply to the equations?

MR. INGLE.—That is a more and more popular situation, due to the advent of the higher-impact plastics.

We adopted a somewhat arbitrary convention and decided from the outset that we would concern ourselves either with reflection or transmittance, but not with both.

Starting with a reflectance measure of this sort, for a pair of opaque samples so thick that further increase of thickness would not change the values, we would make the necessary measurements, and then proceed just as we would in the case of a transparent material.

MR. NEWHALL.—In many translucent specimens, both the transmitted and reflected light must contribute significantly to the color appearance. In such cases, it must be difficult to decide which data to use in calculating the specification. Is there some rule for deciding which to use?

MR. INGLE.—No firm rule, except that in the case of a translucent material of this sort, one is generally interested in a reflected color more than in the transmitting color. For all practical purposes, the two will relate directly and generally enough to be of practical value.

MR. B. A. SILARD.[4]—Would the author say that by substituting true transmission measurements in a liquid that has no turbidity whatsoever his method could give a good approach for grading clear, transparent liquids in one range of color, according to small differences?

MR. INGLE.—I certainly hope so. We draw no distinction between a clear plastic and a clear liquid for purposes of this test.

[1] National Research Council of Canada, Ottawa, Canada.

[2] Photometry and Colorimetry Section, National Bureau of Standards, Washington, D. C.

[3] Eastman Kodak Co., Rochester, N. Y.

[4] Photovolt Corp., New York, N. Y.

Color Methods in the Brewing Industry

By Irwin Stone

A photometric method for the measurement of beer color intensity outlined here is in routine use by a large segment of the brewing industry.

BEFORE partaking of a glass of beer, the consumer's initial observations relate to its color, clarity, and foaminess. Each of these properties is of importance to the brewer in the maintenance of quality and uniformity, and each provides problems in production and measurement.

This paper is limited to a discussion of the measurement of color of beer. This limitation is fortunate because, of the three properties mentioned—color, clarity, and foaminess—the color is the simplest to measure. This also, no doubt, explains why the brewing industry has been able to standardize on a suitable method for measuring color but has not reached any agreement on methods for turbidity or foaminess.

In the past few years the trend in American beers has been toward the production of a beer both milder in flavor and lighter in color. The paleness of the color has made the brewer more and more conscious of the color intensity of the beverage and has brought about a demand for requirements for more precise measurements for maintenance of uniformity than was possible by the older visual matching methods.

Probably the clearest way of describing how the brewing industry arrived at a solution of the problem of beer color measurement will be to give a brief historical summary of the work of a committee of the American Society of Brewing Chemists (ASBC).

Up to several years ago, the visual matching method was the only method available to the industry for the control of the color of its products. The method used in this country and in Great Britain involved matching the sample against glass color slides based on the Lovibond system. In Europe, visual matching against standard iodine solutions or their equivalent in the form of solutions of mixtures of dyestuffs, the so-called Brand dyes, was employed. The recent European Brewery Convention has standardized on a visual matching technique for the color of worts using glass color slides in a comparator, based again on Lovibond colors.

IRWIN STONE for 20 years has been connected with the research laboratories of the Wallerstein Co., New York City and was recently chairman, Technical Committee, American Society of Brewing Chemists.

The method heretofore recommended by the ASBC compared the color of the sample in a cell, ½ in. in depth, with series No. 52 Lovibond glasses, the sample and standard being illuminated by an artificial daylight lamp conforming to certain ASTM specifications. Aside from the fact that the different sets of the standard series No. 52 Lovibond glasses varied in color, there is considerable human error in visually matching a pale beer in a cell of small diameter against glass standards in a fairly strong beam of light. Variations up to 20 or 25 per cent of the total color readings were not uncommon between different technicians in the same laboratory. This, of course, caused much confusion, especially when different laboratories with different sets of Lovibond glasses reported color results on the same samples. In 1944, the ASBC tried to reduce some of the possibilities for misinterpretation by suggesting that color be reported as a range covering 0.2 deg Lovibond instead of a single figure to the first decimal. This reporting practice did not help a great deal.

In 1946, Nissen of Anheuser-Busch (1)[1] who was then chairman of the ASBC Subcommittee on Color and Turbidity, after working out the details in his own laboratory, recommended the use of visual standards prepared from three available dyestuffs. The dye solutions were contained in uniform 4-oz bottles for comparison with the samples. The Society, recognizing the urgent need at that time (Lovibond glasses were unavailable because of war conditions) for something superior to the old visual Lovibond method, adopted this method tentatively as a temporary expedient.

It would be surmised from the facts reviewed that the probable solution of the difficulties would be through the use of photoelectric-instrumental methodology. In the first published report of the ASBC Subcommittee on Color in 1941, the use of photoelectric methods was in fact considered feasible but was not given serious consideration at that time because of the high initial cost of the equipment. Other, and later, publications (2,3,4) indicated the possibilities offered by photoelectric methods.

In 1946, a paper (5) from the Wallerstein laboratories reviewed the subject and indicated the possibilities of the use of a physical definition of color in terms of optical density at a given wavelength. The paper provided a method for the calibration of photometers and for the determination of color in beer. This paper established the basis for later work. As a result, a paper by Stone and Miller (6) presented data for a more thorough treatment of the subject, giving an improved physical definition of beer color and better methods for the calibration of all types of photoelectric colorimeters. The data and methods presented in this paper were accepted in their entirety by the ASBC and constitute its present official method (7).

[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

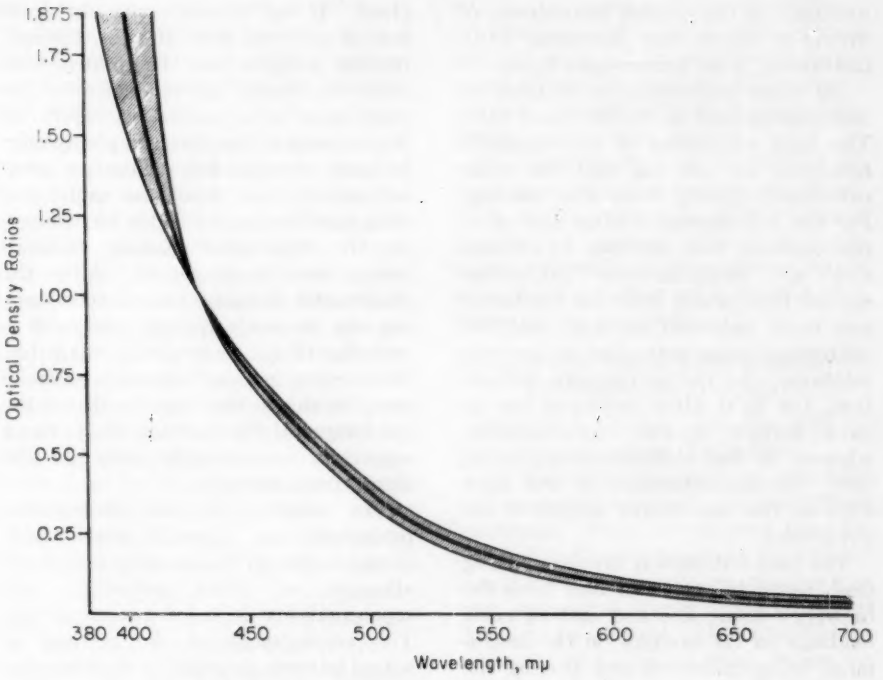


Fig. 1—Spectral Absorption Data from 38 Beers.

The Stone and Miller data were based on a spectrophotometric survey of the color of a representative cross-section of American and Canadian beers. It was found that beer color was surprisingly uniform in its spectral distribution and there was little variation in the light absorption curves. Figure 1 shows the type of spectral absorption curve obtained from the data on the examination of 38 different beers. Since the beers were of varying color intensities, the ratios of their optical densities were plotted using 430 mμ as unity. The dark centerline is the average value, and the shaded areas represent the standard deviations. This curve serves to define the color characteristics of an average beer.

Since the color was fairly uniform among different beers produced by the industry at large, it was possible to set up a purely physical definition of color intensity as follows (6): "Beer color intensity is defined as 10 times the optical density [log $(1/T)$] at 430 mμ wavelength measured in monochromatic light, of a sample of one-half in. thickness, which has the spectral color characteristics of an average beer and is free of turbidity." The terms "monochromatic light," "spectral color characteristics of an average beer," and "free of turbidity" used in this definition were further elaborated. "Monochromatic light" implies a band width of 1 mμ or less at 430 mμ. To have "spectral characteristics of an average beer," the absorption curve will fall within the limits defined by the curve of Fig. 1. For a sample to be considered "free of turbidity," the absorption of light at 700 mμ should be not more than the absorption shown by an average beer of equivalent color intensity; this is easily calculated from the data of the same curve.

With all the variables carefully circumscribed, a definition has been derived that does not require the preparation of any colored solution, color glass, or other artificial standard.

The color values that are obtained by the new photometric method are close to the values that would be obtained by the older visual method so no difficulties resulted from a new color scale during the changeover of methods. The constants in the color definition were specially selected with this end in view.

Two methods were set up: (1) the Standard Reference Method and (2) the Abridged Photometric Method. The Standard Reference Method employs an instrument such as the Beckman Model D.U. Spectrophotometer and is used for precise measurements and for calibrations. The Abridged Photometric Method is the one applicable to all other types of photometers and is the method that may be used

routinely in the control laboratories of breweries where the Beckman D.U. instrument is an unnecessary luxury.

No color calibration is required on instruments such as the Beckman D.U. The light absorption of the sample is measured at 430 mμ and the color calculated directly from this reading. For the less expensive filter and other photometers, two methods of calibration are available—the calibration against beer, which is by far the better and more universal method, and the calibration using potassium dichromate solutions. In the dichromate calibration, the light filter employed has to have certain special characteristics, whereas in the calibration employing beer, the characteristics of the light filter or the wavelength employed are not critical.

The beer calibration involves taking fresh replicate bottles of beer from the brewery's filling line and making color readings on the samples on the instrument being calibrated and also by the Standard Reference Method on duplicate bottles. The Standard Reference color values are made with a Beckman Model D.U. Spectrophotometer at one of the consulting laboratories servicing the industry. A sufficient number of different samples are taken to cover the range of color existing in the particular plant. If the brewery puts out products at only one level of color, the calibration samples may be diluted with water to obtain lighter colors for the preparation of a calibration curve. If the response of the abridged photometer is linear, straight-line calibration plots will be obtained from the calibration data, and the use of a factor for converting the photometer readings to color values can be employed. After the photometer is calibrated, a color reading can be made quickly and with a reproducibility heretofore impossible. When running color tests on a series of samples, this method has eliminated the eye fatigue of the operator, which was a source of considerable error in the older visual methods.

The adoption of this photometric procedure has brought considerable improvement to the brewing industry's attempts to obtain uniformity and reproducibility in color measurements. The employment of the method in actual brewery practice for routine color work has given uniformly good results—probably the best test of the usefulness of any new procedure.

The costs of the cooperative effort in the development and testing of this method were borne by the various cooperating laboratories and breweries. These costs were relatively insignificant in view of the incalculable value of the improvements obtained. It is probable that other groups with color measurement problems similar to those encountered in the brewing industry could solve their difficulties in the same way.

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Color Measurement and Control in the Sugar Industry

By R. A. McGinnis

Significance of color to the sugar industry, and a survey of the methods of measurement commonly employed. The N.C.S.A. method gives reproducible results, but of doubtful accuracy.

The field of color measurement and control in the sugar industry is so vast (1–8)[1] that it is certainly impossible to compress a useful description of it into a short space. Therefore some phases will hardly be mentioned at all, and others will be given very brief treatment. Many aspects and methods which are important only for research purposes are omitted, since the intent is to give background and discuss methods that are significant for practical use in industry.

Importance of Color to the Industry

Although coloring matters are responsible for certain difficulties in sugar technology, such as the retarding of crystallization and the reduction of the fermentability of molasses, the major importance of color to the sugar industry lies in the requirements of the final products.

A very few sugar products must possess definite amounts of color. Soft or brown sugars are purchased for their flavor and color, in addition to their sweetening power. These are made in several roughly standardized intensities of color and flavor and are fabricated either by crystallization from liquors of relatively high nonsugar content, or by coating white granulated sugars with such a sirup. Refiners' sirups, made for table use, must meet similar specifications.

However, the great bulk of sugar products are "white," and in them

R. A. McGINNIS, General Chemist, Spreckels Sugar Co., Woodland, Calif., has been an associate referee of the National Committee for Sugar Analysis subcommittee on Color and Turbidity of Sugar Products.

[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

complete absence of coloring matter is desirable. Some of the white products are designed to be consumed in their crystalline state, or at least to be closely inspected before ingestion. Among these are the large grain specials, which may be sprinkled over bakery goods or confections, various types of cubes, and powdered sugars, which are used in confections and cake icings without undergoing solution. The large grain specials and the crystalline sugars from which the cubes are made are boiled to grain from specially purified mother liquors. Powdered sugars are crushed to their small grain size—a condition in which almost any sugar appears very white.

Granulated sugar makes up about 70 per cent of the refined sugar products sold. Of this 70 per cent, approximately 54 per cent is purchased by the housewife, 35 per cent is used industrially, and the balance goes to the Government and to institutions.

For use in the home, almost any white, granulated sugar found on the market today will give satisfaction, whether it be of cane or beet origin. The actual differences in the whiteness of these sugars are so small that the average housewife is probably never aware of them. This is far from the case in the industrial market, where keen competition between sugar producers has so stressed any small differences between their products that the relative "colors" of the granulated sugars have in some cases assumed exaggerated importance. Granulated sugars are used chiefly in sweetening, jelling, preserving, and dough-raising. The whiteness differentials are insignificant for most of these purposes except where the product is of the low-colored, transparent, or translucent variety. Some fondants, jellies, and carbonated beverages fall within this class.

Color in Sugar Processing

Both sugar-cane and sugar-beet juices contain coloring matters, the latter, however, only in a potential form.

In cane juices (4,7) some of the green plant pigment, chlorophyll, is present, but this is readily removed in processing. Flower pigments known as anthocyanins are also found and, together with other polyphenols, are turned dark green on liming, the result of reaction with traces of iron. These complexes may be changed to brownish shades by enzymes. Colorless amino acids which form brown materials (melanoidins) by reaction with invert sugar are also important (4).

Sugar-beet juices (9,10), although initially colorless, darken rapidly in air from the action of enzymic oxidants on the amino acids present, forming "melanins." Brownish-yellow colors also develop from melanoidins, and an amethyst-green color from polyphenol-iron complexes.

In processing either beet or cane juices, caramel color may be formed from sugar under extremes of temperature and pH, although, normally, caramel occurrence is slight. Much more important are the brown-colored substances formed from the destruction of the invert sugar components, glucose and fructose, on heating in alkaline solution. Since the mixed juice of the cane mill contains many times more invert sugar than beet diffusion juice—a result of innate differences in the vegetable sources—this is a more important problem for the cane processor.

Both types of juices are clarified by the addition of lime. In the case of beet juices, relatively large amounts of lime are added, hot, to give a pH of over 10, and then the excess lime is precipitated with gaseous carbon dioxide. Under this treatment, the small amount of invert sugar is completely destroyed with the formation of colored acidic materials, which are largely removed by adsorption on the calcium carbonate precipitate. Thus the processed beet juice, which starts with a purple-black color, becomes a light yellow.

The cane mill superintendent, on the other hand, with a relatively large amount of invert sugar in his juices, limes only to a slight alkalinity, where about 12 per cent of the glucose and fructose are destroyed. The net result is, nevertheless, a clarified juice with somewhat increased color from polyphenol-iron complexes, the coloring matter from the destroyed reducing sugars having been absorbed by the precipitate. If the beet process is applied without alteration to cane materials, the result is too-heavy formation of nonsugars from the large amounts of invert sugar destroyed. Successful operations may be carried out, however, when less drastic conditions of temperature and alkalinity are used.

The addition of small amounts of sulfur dioxide before concentration of the thin juices assists in preventing the browning reaction between amino acids and invert sugar, while larger quantities will produce a temporary chemical bleaching of many of the coloring materials. One or the other of these practices is followed in beet sugar manufacture.

Following concentration of the juices in evaporators, the sirups are boiled to grain under vacuum. The result in the cane mill is a raw sugar, which is normally further processed in a refinery, where after being washed with water, it is dissolved and most of the coloring matters removed by repeated passages over activated bone char. White sugars are then crystallized from the relatively low-colored mother liquors.

The final product in the case of the beet-sugar factory is white sugar direct. This results from its more vigorous purification process, even though the sugar is crystallized from mother liquors of somewhat higher color content than those of the cane refinery.

Methods of Color Measurement of Intermediate Materials

Only the briefest coverage will be given the subject of this section.

In beet-sugar manufacture, few color measurements are made on intermediate materials. Since the elapsed time between the diffusion juice and the finished sugar is only a few hours, the color of the granulated sugar produced serves for process control. Occasionally the colors of the thin or thick juices are determined.

Color measurement of cane refinery liquors and sirups is of greater importance. Here, in addition to its own significance, the color may serve as a rough indication of the nonsugar contents, and the routing of liquors through the bone char filters is frequently controlled by color measurements.

A great diversity of methods is used. Simple cylinder comparisons with fixed or liquid standards; comparators of the Dubosc type; abridged spectrophotometers, both photoelectric and visual; tintometers; and others are used. While greater uniformity of these methods is unquestionably desirable, nevertheless, presumably each manufacturing unit now has methods for color measurement of intermediate materials which satisfy its needs.

The measurement of color in raw cane sugars is of considerable importance and has been the subject of many studies. A currently recommended method is that of Zerban (11).

Methods of Color Measurement of White Sugars

Variety of Methods in Use:

Table I, based on a partial survey of the industry (12),[2] gives some idea of the diversity of equipment in industrial use for the measurement of color of white sugar products.

Reflectance Measurements:

There can be little doubt that if a measure of the visual color of white

[2] Personal survey among U. S. beet-sugar manufacturers (1952).

TABLE I.—COLOR MEASUREMENT PRACTICE IN THE SUGAR INDUSTRY.

INSTRUMENTS AND REFERENCE STANDARDS

Reference Standards	Photoelectric Instruments	Visual Instruments
Distilled water	12	0
Colorless sugar solution	8	0
Other (colored solutions, etc.)	1	12

INSTRUMENTS AND AUXILIARY OPERATIONS

Auxiliary Operations	Photoelectric Instruments	Visual Instruments
Filtration		
Yes	1	1
No	20	11
Turbidity correction		
Yes	15	1
No	6	11
pH adjustment		
Yes	3	0
No	18	12

SPECTROPHOTOMETERS AND WAVELENGTHS

Wavelength, mμ	Spectrophotometers	Abridged Spectrophotometers
425	1	3
560	2	0
420–725	5	5
450–660	0	4
535–660	0	1

granulated sugars is required, a "psychophysical" trichromatic system is indicated, such as the CIE with its tristimulus coordinates, or the Ostwald, Munsell, or Lovibond systems. Furthermore, the analytical data should be obtained from reflectance measurements. It is found that the character and amount of light reflected from a mass of sugar crystals at any given angle depend not only on the light-absorptive properties of the individual crystal faces, but also on the average size and the size distribution of the crystals; on the moisture content of the sugar; on the closeness of the crystal packing; on the color of the container (unless the sample layer is quite thick); on the proportion of fractured crystals; and doubtless on other factors.

This should not occasion concern, except that the sugar technologist, whether producer or consumer, is fundamentally not nearly so interested in true visual appearance as he is in the amount of colorant present, because in the important uses where color makes a difference, granulated sugar is dissolved. When sugar is dissolved, only the factor involving the amount of colorant present affects the product appearance.

While granulated sugar reflectivity has been and is measured in a very few laboratories, the results of the measurements do not have important industrial usefulness (13,14,15).

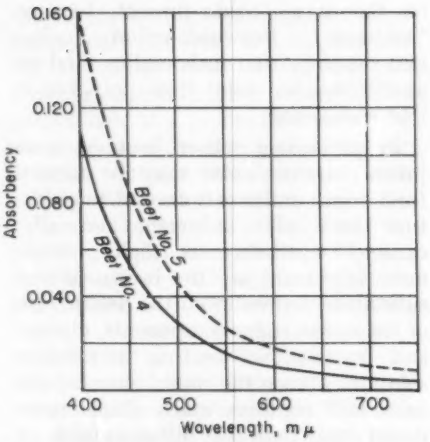

Fig. 1.—Absorbancies of Beet Granulated Sugar Solutions, Filtered, from 400 to 750 mμ. (Reference standard: clear, colorless sugar solution, 50 per cent solutions, 5-cm cell.)

In many beet factories, however, direct visual examinations serve as the major product controls. Such determinations are usually carried out under some sort of controlled illumination, such as a daylight-blue tungsten lamp in a reflector, and the analyst is frequently the factory superintendent. Two conical piles of sugar are laid side by side, one of the standard and the other of the unknown, and the vertices are pressed down with some flat object until the piles are in contact. Thus two immediately adjoining fields are presented, and, of course, under such conditions the eye can detect very small differences with considerable precision. Some manufacturers maintain stocks of "standard" sugars in several intensities of "color" for comparison, while others use only one. This simple procedure yields thoroughly practical results.

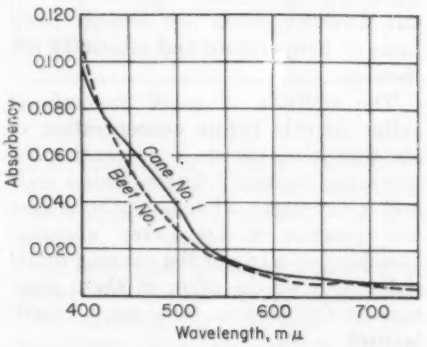

Fig. 2.—Absorbancies of Cane and Beet Granulated Sugar Solutions, Filtered, from 400 to 750 mμ. Such differences in curve shape are frequently found. (Reference standard: clear, colorless sugar solution, 50 per cent solutions, 5-cm cell.)

Aside from the above, however, all color measurements in the white sugar field are made on solutions.

Solution Color Measurements—Nomenclature:

The nomenclature in current use for spectrophotometric measurements in sugar solutions has been developed by a number of workers at the National Bureau of Standards (16,17,18) in cooperation with other scientific societies. The following is that now accepted for use by the Bureau and by the National Committee on Sugar Analysis.

Transmittance (T).— the ratio of the transmitted flux to the incident flux.
Transmittancy (T_s).— the ratio T_{soln} to $T_{solv.}$
Absorbancy (A_s).— $-\log T_s$.
Absorbancy Index (a_s).— A_s/bc, where b is the cell length in centimeters and c is the concentration of total solids in grams per milliliter.

These units may be used only when there is no scattering of light in the solutions. Since there is almost invariably light scattering in sugar solutions due to suspended or colloidal particles, and to a lesser extent to dissolved molecules, the following units are applicable:

Attenuancy (A_c*).— $-\log T_s$.
Attenuation Index (a_c*).— $-\log T_s/bc$.

Factors Affecting Solution Colors:

Nature of Absorption Curves.—The spectral absorption curves of solutions of all types of sugars are similar in shape; this is particularly true with solutions of refined sugars. Absorption is high in the ultraviolet (Figs. 1 and 2), falling off steadily on what appear to be power curves to low absorptions in the infrared. Marked irregularities are frequently found in the ultraviolet and infrared regions.[3]

Because of the similarity in curve shapes, it is possible to measure absorbancies at a given wavelength and to find the results satisfactorily proportional to visual brightness, purity, and dominant wavelength. The classic work in this field was that of Peters and Phelps (16), who showed that 560 mμ represents the "center of gravity" for sugar solution absorption curves, and whose recommended method involved absorbancy measurements at that wavelength on solutions mechanically cleared of turbidity. Zerban (19) confirmed this work and showed by statistical analysis of many data that the color of a refined sugar solution, as seen by the eye, may be determined by measuring the absorb-

[3] Data presented by J. A. Devlin and R. W. Liggett at the Fall, 1952, Meeting of the American Chemical Society.

ancy at 560 mμ and at no other wavelength. Since the use of abridged spectrophotometers readily permits measurements of absorption at this wavelength, the problem would seem to be solved for practical purposes, excepting for the factor of turbidity.

Turbidity.—Absorbancies cannot be measured in solutions in which there is light scattering, and thus the execution of the method of Peters and Phelps involves removal of the material causing the turbidity. This is accomplished by mechanical filtration of the solutions through specially prepared asbestos pads (20). The resulting filtrates are, for practical purposes, free from all but molecular scattering. Because of the care with which all phases of the filtration must be made, and because of the prolonged time of filtration (about 1 hr), the method is impractical for industrial use. In addition to this objection, there have been indications that, depending on slight variations in the details of preparing the asbestos pad, different degrees of turbidity removal will be reached. Zerban (21) showed that the materials causing light absorption and scattering are not necessarily different. It is clearly erroneous to assume that particles causing turbidity do not have an effect on color absorbancy and *vice versa*. It is certain that at least small amounts of color are lost in filtration through any known filtering medium, whether through adsorption of coloring matter on the surface of the filter aid or by removal of colloidal material responsible for both color and turbidity.

Concentration.—It is apparent that the more sugar dissolved in the solution the greater will be its light absorption due to color. Since white sugar products contain only small amounts of colorants (the granulated sugar of the grocery store, except for about 0.02 per cent moisture, contains only 0.005 to 0.02 per cent total impurities), it is desirable to make up as concentrated a solution as is convenient, for maximum photometric accuracy.

Early investigations (16) showed that colloidal nonsugar coloring matter is most stable at a concentration of approximately 0.7 g dry substance per milliliter volume or 55 deg Brix. At other concentrations there is apparently a greater tendency for the coloring matter to change its degree of dispersion. A third, practical factor favoring a concentration in this range is the speed with which equal weights of sugar and water can be measured by weighing against each other, without any precise weight values being used. Thus a concentration of 50 per cent is in common use.

If the amount of colorant in such a solution is too great for convenient measurements, dilution should be made not with water but with 50 per cent colorless, clear sugar solution, prepared as described later.

pH.—A colorimetric, pH-indicator effect is shown by most sugar colorants, with reduction in color as the pH is changed from the alkaline toward the acid regions. The color "as is" is best measured at the existing pH, but for precision comparisons it is better to make all measurements at a uniform pH value, and in such cases it is customary to adjust the pH to about 7.0 with dilute solutions of sodium hydroxide or hydrochloric acid.

Dissolving Water.—The water in which the sugar is dissolved must not make contributions to color or turbidity. Sugars can be dissolved much more rapidly in hot water from which air has been expelled by boiling. When the sugar is dissolved, the solutions are quickly cooled to room temperature before analysis. While many investigators have shown that an increase in color accompanies the use of hot water, this may be partly the result of more complete dispersal of dried colorants; in any case the effect is small enough to be ignored in industrial work.

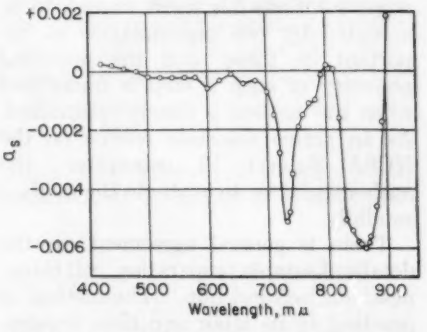

Fig. 3.—Dependence of Absorbancy upon Wavelength for a Purified Sucrose Solution (0.778 g per ml) Measured Relative to Distilled Water in a 10-cm Cell. (From V. R. Deitz, N. L. Pennington, and H. L. Hoffman, Jr., *Journal of Research*, Nat. Bureau Standards, Vol. 49, p. 366 (1952), by permission.)

Reference Standards.—The reference standard for the spectrophotometric measurements should be a clear, colorless sugar solution. Because of the difficulty of its preparation and because, once made, it rapidly degrades optically it is not normally practicable to use it for routine work. If water is used, certain corrections must be made. Figure 3 shows absorbancy data (18) from 600 to 800 mμ for a purified sucrose solution, measured against pure water as a reference standard. The absorption bands in the infrared are due to harmonics in the absorption spectrum of water and appear because the sucrose solution in this case contains only about 40 per cent water. When water is used as a working reference standard, some such correction curve must be determined and used.

Two-Color Measurement Methods:

The troublesome complications involved in physically removing the turbidity-forming material from sugar solutions make optical methods attractive. Here corrections for turbidity may be applied to determinations made on unfiltered solutions.

The most promising methods of this type are those involving spectrophotometric determinations at two wavelengths. These methods are all based on the facts that (*a*) sugar-solution colorants absorb light strongly in the blue end of the spectrum and very weakly in the red end; and (*b*) sugar-solution turbidants attenuate light over the whole visible spectrum, although increasingly so with shortening wavelength. Thus attenuancies in the blue region are due to the effect of both colorants and turbid material, whereas in the red region the attenuancies are due chiefly to turbidity.

The first of these methods introduced into practical use in this country was that of Keane and Brice (14), in which the assumption is made that the attenuation of light due to turbidity is the same in the blue-green and red and that there is no absorption due to color in the red. Broad-band light filters are employed with optical centroids at 535 and 660 mμ. This method is still in limited use.

Nees (22) proposed a correction for the unequal scattering of light at the two end regions of the visible spectrum, using short-length absorption cells. Morse and McGinnis (23,24) applied experimentally determined corrections to each of the spectrophotometric measurements using the filters of Keane and Brice; they assumed, with the others, constancy of colorant absorption-curve shape and constant turbidant characteristics. Both these methods are still in active use in the factories of the manufacturers who sponsored the procedures, and they have proved quite practical.

Gillett, Meads, and Holven (25) described an abridged spectrophotometric method in which the red measurement is made in the infrared at 720 mμ and the blue at 420 mμ. Under these conditions their supporting data showed

(*a*) that there is no appreciable absorption at 720 mμ due to color, and (*b*) that the attenuation index at 420 mμ could be corrected for turbidity by subtracting twice the attenuation index at 720 mμ. This method is of considerable importance, since in modified form it has come into more general use at the present time than any other.

NCSA Method.—The National Committee for Sugar Analysis, which is the United States unit of the International Commission for Uniform Methods of Sugar Analysis, has within it a subcommittee on Subject 13, Color and Turbidity of Sugar Products. The subcommittee has been working steadily on this problem for many years. Under the leadership of T. R. Gillett chairman, the subcommittee presented (12) to the National Committee in March, 1953, a method based on that of Gillett, Meads, and Holven (25), which it recommended only as a temporary, interim procedure because of certain questionable features. The National Committee accepted the method as presented, and it has also been adopted by the American Bottlers of Carbonated Beverages.

This method, which is intended for practical industrial use only, will be given in detail (12).

"(1) *Sample preparation.* (*a*) Dissolving Water: Good quality boiled distilled water at a temperature of 90–100 C. The water should be added to the sugar and the mixture gently stirred to bring it into solution. Cool solution to about room temperature before measurement. Note: Stainless steel or glass bottles or beakers should be used. Aluminum beakers should not be used as they introduce turbidity. (*b*) Concentration: 50 per cent solids ± 0.2 per cent.

"(*c*) Filtration: No filtration should be made. (*d*) pH Adjustment: No pH adjustment to be made and sugar to be tested at original pH value.

"(2) *Measurement.* (*a*) Cell Thickness: 10 cm. (*b*) Type of Instrument: Beckman DU Spectrophotometer or its equivalent. (*c*) Wavelength: 420 mμ and 720 mμ. (*d*) Cell Location: The sample cell should be located as close to the photocell as possible. (*e*) Reference Standard: A 50 ± 0.2 per cent solids colorless sugar solution. For practical purposes, the reading with a colorless sugar solution may be correlated with a secondary standard such as distilled water or air and a balance point established on the scale which will give the equivalent of a colorless sugar solution. (*f*) Readings: Determine per cent transmittancy at the specified wavelengths.

"(3) Expression of Results: Calculate and report as follows: (*a*) absorbancy at 420 mμ = $-\log T_{420}$. (*b*) Absorbancy at 720 mμ = $-\log T_{720}$. (*c*) Color Index (compensated for turbidity) = $1000\,(-\log T_{420} - 2(-\log T_{720}))\,/bc$, where b = cell thickness (cm); c = concentration (g/ml); T = per cent transmittancy."

Preferred Method for Preparation of a Clear, Colorless Sugar Solution.—Weigh 360 g of confectioners white sugar (if granulated sugar is used, the Darco decolorization step must be repeated). Filter after each decolorization into a Pyrex beaker, add 356 ml of hot distilled water (90–95 C), and stir until thoroughly dissolved. Defecate with 3.6 ml of dilute phosphoric acid (44 g—75 per cent phosphoric acid per liter) and enough calcium hydroxide to adjust the pH to 8.0 ± 0.2. Stir to complete the defecation. Place in a hot water bath (70–80 C). Add 6 g (1.5 per cent on dissolved solids) Darco S-51 and leave in the bath for 1 hr with frequent stirring. Add one heaping tablespoon of kieselguhr and filter through a double thickness of filter paper. Adjust the density of the solution to 50 ± 0.2 per cent solids and the pH to 7.0 ± 0.2. Polish filter by passing the solution through a "fine" sintered glass filter.

Discussion.—It is an important advance for the sugar industry that a method of determining the color of white sugar solutions has merit enough to be accepted by two organizations as important as these, and the impelling necessity of such a step is underlined when the method is closely scrutinized. As an active associate referee on the NCSA Subject 13 committee, the author feels free to evaluate the method candidly.

There is general agreement on the details of sample preparation, cell thickness, and cell location. The method is practical in its labor and time requirements. The precision of the method is adequate. During the studies (12) six laboratories made determinations using this method on two samples each of beet and cane refined sugars. Table II summarizes the results. Even though such precision would be inadequate for research purposes, it is quite satisfactory for industrial use.

TABLE II.—TEST OF REPRODUCIBILITY OF NCSA METHOD.

Wavelength, mμ	Average Deviation ($-\log T/bc$)	Per Cent of Average Reading
420	±0.0010	± 3.0
560	±0.0008	± 7.5
720	±0.0006	±11.3
Color Index	±0.9	± 4.0

On the other hand the method is susceptible to criticism when its accuracy is considered. As stated, the method involves the primary assumption that if twice the attenuancy at 720 mμ is subtracted from the attenuancy at 420 mμ, a satisfactory correction has been made for turbidity. This assumption in turn rests on two implications:

1. There is negligible light absorption due to colorants at 720 mμ.
2. The turbidity correction factor is 2.

Gillett, Meads, and Holven (25) determined the magnitude of the correction factor by adding molasses coloring matter, which presumably was free of turbid material, and suspensions of bentonite, to clear, colorless sugar solutions. This method of determining the correction factor is open to the criticisms (*a*) that addition of molasses colorant may result in turbidity change due to alteration of colloidal dispersion, and (*b*) that there is no assurance that turbidities naturally occurring in sugar products will resemble in particle size distribution and other factors those produced by bentonite suspensions (according to Rayleigh's equation (26), scattering of light is proportional to the 6th power of the particle radius).

Table III lists data obtained by the author during the course of subcommittee work, using a contrasting method, in which the correction factor was determined by making spectrophotometric determinations before and after mechanical filtration to remove turbidity. This means is subject to the criticisms that (*a*) the amount of turbid matter removed varies somewhat with the tightness of the filtration, and (*b*) small amounts of colorant may be removed by the filtration. The author prefers this method because it permits accuracy checks at any time on actual sugar solutions with natural turbid matters.

Referring to Table III, the assumption that there is negligible light absorption due to colorants at 720 mμ, as shown by the relative magnitude of the values in column 4 compared with those in column 3, is not entirely justified. Samples 11 to 16 are cane sugars, and in these cases the absorbancies due to color at 720 mμ, column 4, are reasonably small and constant. This is not the case for the beet sugar samples.

The ratios in column 8, testing the validity of the assumption that the turbidity correction factor is 2, should be 2.0. It will be noticed that this value is much more closely approximated for cane sugars and appears to be appreciably lower for beet sugars. Examination of the values in column 6 shows that errors resulting from the use

TABLE III.—ABSORBANCY AND ATTENUANCY INDEXES AND DERIVED DATA.

Sample	Source	Unfiltered Solutions		Filtered Solutions		N.C.S.A. Color $1000[(1) - 2(2)]^a$ (5)	Error $[(5) - 1000(3)]$ (6)	Blue Turbidity Increment (7)	Ratio $[(7)/(2)]$ (8)
		420 mμ (1)[a]	720 mμ (2)	420 mμ (3)	720 mμ (4)				
No. 1	Western Beet	0.059	0.008	0.054	0.006	43	−11	0.005	0.62
No. 2	Midwestern Beet	0.042	0.008	0.036	0.003	26	−10	0.006	0.75
No. 3	Midwestern Beet	0.047	0.008	0.038	0.003	31	− 7	0.009	1.12
No. 4	Midwestern Beet	0.043	0.005	0.038	0.002	33	− 5	0.005	1.00
No. 5	Rocky Mountain Beet	0.053	0.008	0.045	0.003	37	− 8	0.008	1.00
No. 6	Rocky Mountain Beet	0.028	0.005	0.025	0.003	18	− 7	0.003	0.60
No. 7	Michigan Beet	0.051	0.013	0.029	0.004	25	− 4	0.022	1.69
No. 8	California Beet	0.036	0.008	0.030	0.003	20	−10	0.006	0.75
No. 9	California Beet	0.025	0.005	0.021	0.005	15	− 6	0.004	0.80
No. 10	California Beet	0.036	0.006	0.032	0.005	24	− 8	0.004	0.67
Averages				0.035	0.004		− 8		0.90
No. 11	California Cane	0.033	0.004	0.023	0.001	25	+ 2	0.010	2.50
No. 12	Louisiana Cane	0.078	0.011	0.042	0.002	56	+14	0.036	3.27
No. 13	Louisiana Cane	0.057	0.008	0.040	0.002	41	+ 1	0.017	2.13
No. 14	Louisiana Cane	0.051	0.006	0.040	0.002	39	− 1	0.011	1.83
No. 15	Michigan Cane	0.051	0.012	0.028	0.002	27	− 1	0.023	1.92
No. 16	Louisiana Cane	0.041	0.007	0.028	0.002	27	− 1	0.013	1.86
Averages				0.034	0.002		+ 2		2.25

of the NCSA method may be appreciable.

Thus, while the reproducibility of the NCSA method is satisfactory, its accuracy may be in some doubt. This is, of course, true of all two-color methods, since all assume constancy of color-absorption curves and uniform turbidants.

In addition, contributions to inaccuracy may come from the selection of the particular wavelengths used. The blue (420 mμ) is on a very steep part of the absorption curve, and, conceivably, measurements at this point may fluctuate considerably with relatively small displacements from this wavelength. On the other hand, measurements at this point have the advantage of high sensitivity. If a wavelength near 560 mμ had been selected, the attenuancies would be more nearly a measure of true visual color, as indicated by the findings of Zerban (19), but the sensitivity to color differences would be somewhat reduced.

The selection of the 720 mμ point may be criticized because (*a*) as shown by Fig. 3, an absorption band of pure water occurs at this point, and in the case of sugar solutions with very low color and turbidity, variable and even negative values may be (and have been) obtained. (*b*) Photometers using barrier-type photocells are not sensitive at this point. Practically, this means that only a relatively few, expensive instruments may be used. Absorptions due to color at, let us say, 680 mμ, are only slightly greater than at 720 mμ (Fig. 4), and the use of 680 mμ would permit most standard colorimeters to be utilized.

Conclusion

The need of the sugar industry and industrial sugar consumers for a practical method of determining the color of white sugar products is very great.

A precise and accurate method of color-grading white sugar products is economically important, because in the competitive market now existing it is often used as a criterion for the acceptance or rejection of a sugar product by the customer.

The strongest competition is for the local markets, where no freight absorption by the manufacturer is required. It is unpleasant enough for a manufacturer to be forced to pay additional freight costs to sell his product because it is off-grade; but to have this occur unjustly, because of intrinsic inaccuracy in the grading method, is surely unnecessary loss.

It is very difficult to evaluate color measurement in terms of dollars and cents, and it will not be attempted here, but it can be safely said that an inaccurate color measurement can cost the manufacturer a considerable portion of his anticipated profit.

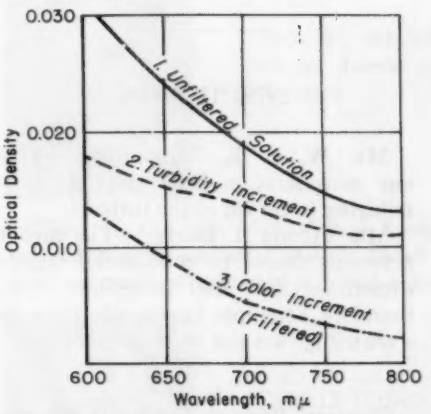

Fig. 4.—Optical Densities of a Granulated Sugar Solution, Filtered and Unfiltered, Showing the Absorption Increments Due to Color and Turbidity, from 600 to 800 mμ. (Reference standard: clear, colorless sugar solution, 50 per cent solutions, 5-cm cell.)

Measurements of reflected light are unsuitable, being too greatly influenced by factors other than the amount of colorant present. In addition, the important uses of granulated sugar, where color is a factor, involve its water solutions.

In color measurements of solutions, psychophysical, triparameter methods are too complex for routine use, but absorbancies at 560 mμ are close measures of visual color.

Unfortunately, light scattering interferes with absorbancy measurements. If the attempt is made to remove turbidity-causing materials by mechanical filtration, difficulties are encountered, since some substances apparently can be responsible for both color and turbidity contributions. Thus, very close mechanical filtrations will remove small amounts of color; in addition they are time-consuming.

Methods involving attenuancy measurements at two wavelengths of light are the center of attention at present. By the use of these methods, a correction may be applied for turbidity. Such methods encounter the primary difficulty that the types of colorants and turbidants in sugar solutions are not always uniform. Methods of this type so far proposed have assumed uniformity and have failed in so far as that assumption is in error.

Progress in the field of white sugar colorimetry has been made as the result of intensive work on the part of many individuals, especially as concentrated in certain scientific organizations, such

as the Bureau of Standards and the National Committee on Sugar Analysis.

The fact that one method has won widespread acceptance within the past year is gratifying, and the fact that the method involved has imperfections emphasizes the great need for a precise and truly accurate method.

It appears likely that the ideal method we are seeking will involve spectrophotometric measurements of sugar solutions, probably in a spectral region where absorbancies will be proportional to visual color, and that the turbidity correction constitutes the main problem which must be solved.

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DISCUSSION

MR. W. E. K. MIDDLETON.[1]—Has any consideration been given to centrifuging to get rid of the turbidity?

MR. VICTOR R. DEITZ.[2]—The turbid materials found in commercial sugars sometimes float and sometimes sink; therefore, attempts to separate these in a centrifuge are not very satisfactory.

[1] National Research Council of Canada, Ottawa, Canada.

[2] National Bureau of Standards, Washington, D. C.

Radiographic Properties of X-rays in the Two- to Six-Million-Volt Range

By C. H. Goldie, K. A. Wright, J. H. Anson, R. W. Cloud, and J. G. Trump

Steady increase in the thicknesses of metal fabrications requiring radiographic inspection dictates the use of higher X-ray energies.

THIS investigation was prompted by the awareness that the hitherto unexplored X-ray region of from 2 to 6 million volts, still dominated by the Compton absorption process, offered advantages in radiographic speed, sensitivity, and latitude for the examination of heavy metal sections. In 1945 the High Voltage Laboratory under Van de Graaff at the Massachusetts Institute of Technology completed an experimental and analytical study of radiography with 0.5-million to 2-million-volt X-rays (1).[1] The extension of this radiographic study to 6 million volts was supported by the Office of Ordnance Research and was facilitated by the availability at MIT of both a 3-million-volt Van de Graaff X-ray source and the Office of Naval Research Van de Graaff accelerator which covered the 4-million to 6-million-volt X-ray range.

Absorption and Scattering of X-rays

The dominant absorption mechanism in the lower million-volt X-ray range by which photons are diminished in energy and scattered is the Compton effect. In these interactions, dependent primarily on electron density, the photon collides with and imparts energy to an atomic electron, and then proceeds in an altered direction with correspondingly diminished energy. These modified photons are the principal source of scattered radiation.

In this energy range the pair-production mechanism of X-ray absorption in steel is a lesser factor. In this process the photon energy is converted into the rest mass of two electrons which carry away the remainder of the incident photon energy. Pair-production first appears at 1.02 million volts, the rest energy of two electrons, and thereafter increases with photon energy and the atomic number of the absorber. For 6-million-volt photons, for example, pair-production process in iron causes about half as much absorption as Compton process, while in lead, pair-production absorption is about 50 per cent greater than Compton absorption for this energy (2). The positive electron produced in this process disappears at the end of its path by combining with an atomic electron somewhere in the absorber, usually with the emission of two photons of 0.5 million-volts energy. This annihilation radiation is another source of scattered radiation in the high-energy region.

The photoelectric process, which is the principal absorption mechanism for X-rays below 100 kv, particularly with heavy metals, is negligible in the million-volt region.

The direct, or picture-bearing, radiation emerging from an absorber is that portion of the incident radiation still traveling in the original direction. It is the radiation which would emerge if all interactions were complete absorption processes. Unfortunately the scattered radiation produced within the absorber contributes greatly to the emerging radiation, but serves only to fog the film. The total transmitted beam is the sum of this direct and scattered radiation.

A monochromatic direct X-ray beam would be attenuated in an absorber according to the relation

[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

CHARLES H. GOLDIE, Contract Engineering Division, High Voltage Engineering Corp., Cambridge, Mass. Recently engaged in research and development of Van de Graaff accelerators at MIT.

KENNETH A. WRIGHT, High Voltage Research Laboratory, MIT, specializes in application of high energy radiation to biological systems.

JOHN H. ANSON, radiation physicist, Los Angeles Tumor Institute. Former member of the MIT High Voltage Research Laboratory.

ROBERT W. CLOUD, High Voltage Research Laboratory, MIT, engaged in development of Van de Graaff accelerators with emphasis on problems associated with high-voltage acceleration tubes.

JOHN G. TRUMP, Professor of Electrical Engineering and Director of High Voltage Research Laboratory, Massachusetts Institute of Technology. Pioneer in development of the Van de Graaff accelerator as a compact supervoltage radiation source for X-ray therapy.

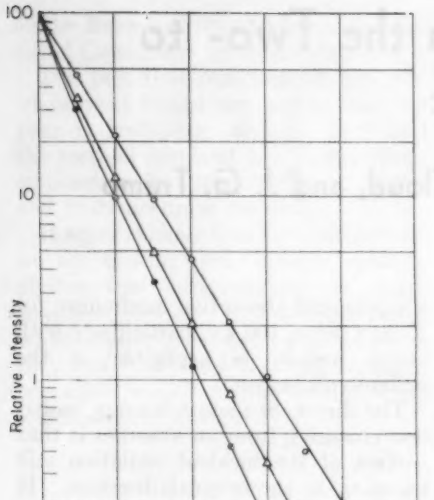

Fig. 1.—Direct-Beam Transmission Curves in Steel for 2-, 3-, and 6-megavolt X-rays.

down to about 0.1 per cent of the incident intensity. It is technically impossible to carry the direct-beam transmission measurements far enough to reach the absorption coefficient of the highest-energy radiation in the beam.

Total-beam transmission curves are quite different in appearance. The total radiation includes both the direct-beam and the scattered radiation which increases rapidly in the first small absorber thicknesses. As seen in Fig. 2, this semilog curve becomes progressively steeper until a few inches of steel have been traversed, after which it becomes virtually straight.

Feshbach (3) has suggested that this straight semilog plot indicates that an equilibrium is reached between the higher-energy components of the transmitted beam and their accompanying scattered secondaries, after which the total beam behaves as if it were a monochromatic beam having an energy equal to the highest energy in the continuous spectrum. It should be noted that at infinite thickness of absorber both the direct- and total-radiation curves should have the same slope.

Within the range of thickness for which accurate detection of the radiation can be accomplished, it has been

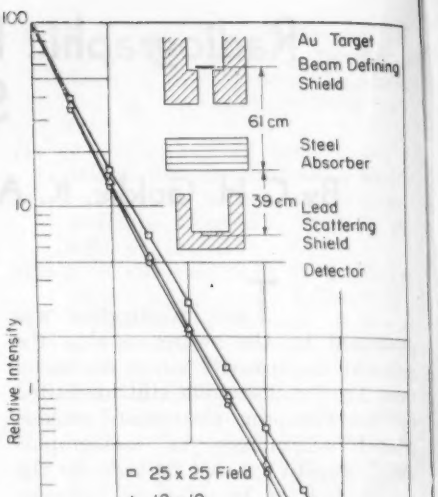

Fig. 3.—3-Megavolt X-ray Transmission Curves in Steel for Different Field Sizes with Direct-Beam Setup.

$$I = I_0 e^{-\mu x} \quad \ldots\ldots\ldots\ldots (1)$$

where:

I = the intensity at depth x in the absorber,
I_0 = the incident intensity, and
μ = the linear absorption coefficient.

The logarithm of the monochromatic direct-beam intensity plotted against absorber thickness is a straight line of slope μ.

The continuous radiation spectrum from an X-ray target contains photons of all energies up to the maximum tube voltage. Since the linear absorption coefficient, μ, diminishes steadily with increasing photon energy (until about 7 million volts for iron), the selective absorption of the less energetic photons shifts the spectrum of the direct radiation toward the short wavelength limits. This shift toward the high-energy end of the spectrum soon becomes extremely slow; the direct-beam transmission curve plotted as in Fig. 1 becomes almost a straight line, and the beam behaves as essentially monochromatic radiation. Thus, any direct X-ray beam, after sufficient initial absorption, can be described by an effective absorption coefficient, μ_D. The value of μ_D is usually obtained from direct-beam curves which extend

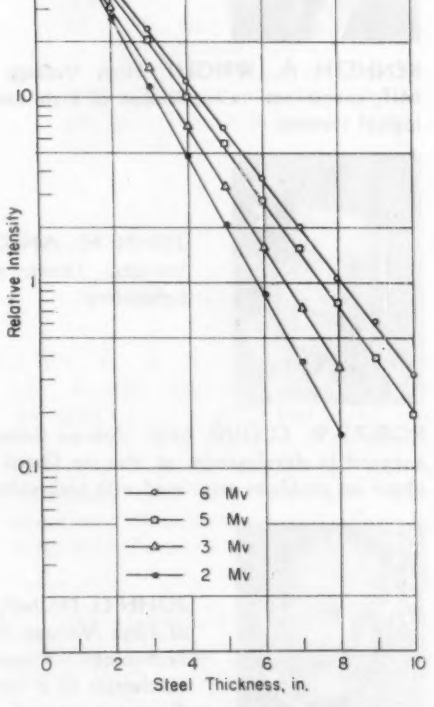

Fig. 2.—Total-Beam Transmission Curves in Steel for 2-, 3-, 5-, and 6-megavolt X-rays with a 25 by 25-cm Field.

experimentally found for 1- and 2-million-volt X-rays that the ratio of the scattered radiation to the direct is proportional to the thickness of the absorber (4).

Experimental Apparatus and Procedure

The X-rays from both Van de Graaff accelerators had an equivalent filtration of about 11 mm of lead, most of which was in the $\frac{1}{4}$-in.-thick gold targets. With the ONR[2] generator, working space was gained by magnetically deflecting the electron beam through 90 deg before allowing it to strike the target. The 3-million-volt X-ray generator was calibrated for negative operation, and the two lower voltages, which were obtained with this machine, are known to an accuracy of better than ±3 per cent. Although the ONR machine was very accurately calibrated for positive ion operation, estimated accuracy for its operation as an X-ray source for the 5- and 6-million-volt data is ±5 per cent.

The X-ray energy incident on the absorber was monitored with a thin-wall flat ionization chamber placed in the field close to the X-ray target

[2] Financed by the Office of Naval Research, operated by the MIT Laboratory of Nuclear Science and Engineering.

and connected to a remote modified Shepard-Roberts d-c amplifier. A special flat ionization chamber with adjacent preamplifier and remote amplifier and indicating circuit was used to measure the transmitted intensity. This detector was shaped to approximate the conditions of actual radiography, the mean depth of its thin, flat air cavity being about the same distance beneath the bottom of the steel plates as a film in a pressure cassette.

For the direct-beam measurements, the detector was placed remote from the steel absorber and surrounded with a 3-in.-thick lead shield to reduce approaching scattered radiation. The 2- and 3-million-volt transmission curves were obtained with fields defined to 4 by 4, 10 by 10, and 25 by 25 cm at the detector with setup dimensions as indicated in the inset of Fig. 3. The 3-million-volt curves are shown in Fig. 3. The small difference between the transmission of the two smaller fields suggests that the 4 by 4-cm data can be accepted as the direct-beam curve with only small error. Because of the poorer electron-beam focus in the ONR accelerator, the field size used for the direct-beam measurements at 5- and 6-million volts was increased to 6 by 6 cm, the target-to-detector distance increased from 100 to 135 cm, and the distance from absorber to detector from 39 to 62 cm. Under these conditions the detector chamber had a somewhat smaller solid angle for scatter from the steel plates.

The total-beam data were taken for three fields for the two lower voltages and for two fields for the higher voltages. In these measurements the target-to-detector distance remained the same as in the direct-beam situation, but the steel was stacked directly against the lead block containing the detector. This lead block, in which the chamber was embedded, provided protection from general room scatter. In practice this is also done to the film cassette in a radiographic setup.

Results of Direct- and Total-Beam Measurements

Figure 1 shows the direct radiation as a function of steel thickness for 2-million, 3-million, and 6-million-volt X-rays. The focus of the electron beam in the ONR machine had been adjusted for 6-million-volt operation and was left unadjusted at 5-million volts with resultant defocusing and error in the 5-million-volt direct-beam data. Unavailability of the ONR machine prevents the repetition of this run. The direct-beam curves are sufficiently straight to permit the calculation of an absorption coefficient and an "equivalent energy." Table I lists the direct-beam linear absorption coefficient, μ_D, and the energy in million-electron-volt units of the monochromatic radiation which would have the same absorption coefficient.

TABLE I.—EFFECTIVE ABSORPTION COEFFICIENT AND "EQUIVALENT ENERGY" OF DIRECT BEAM.

Tube Voltage, megavolts	Direct Beam Absorption Coefficient, μ_D, in.$^{-1}$	Equivalent Monochromatic Energy, mev
2.....	1.04	1.30
3.....	0.90	1.75
6.....	0.77	2.50

Figure 4 shows the total transmitted radiation as a function of thickness for 4 by 4, 10 by 10, and 25 by 25-cm fields of 3-million-volt X-rays, and Fig. 2 shows the total transmitted radiation for the 25 by 25-cm field with 2-, 3-, 5-, and 6-million-volt X-rays. The plots are essentially straight lines on the semilog paper. These two figures demonstrate the considerable dependence of total transmitted radiation on both field size and voltage. The total-beam absorption coefficients calculated from the slopes of the 25 by 25-cm data in Fig. 2 are compared in Table II with the theoretical absorption coefficients for a monochromatic beam with energy equal to the maximum energy of the continuous spectrum (2). The fairly close check is similar to that found by the Office of Scientific Research and Development group for 1- and 2-million-volt X-rays with a 25-cm diam round field, and is in agreement with Feshbach's theory. It is probable that a larger field must be used to approximate the condition of irradiating an absorber with an infinite field in order to bring about Feshbach's "equilibrium distribution." Even so, the total-radiation semilog plots are close to straight lines, although the measured absorption coefficient remains slightly higher than the limiting value for that voltage.

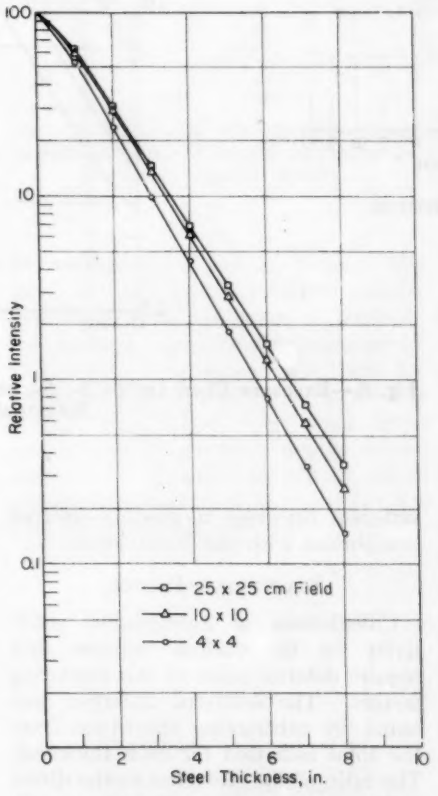

Fig. 4.—3-Megavolt Total X-ray Transmission Curves in Steel for Different Field Sizes.

X-ray Intensity and Exposure Time

Since most radiography is done with fields at least as large as 25 by 25 cm, this field size and a commonly used high-quality film, Eastman Type A Industrial Radiographic Film, were chosen for the calculation of an exposure chart. Type A film requires a radiation dose of 4 roentgens to produce a film density of 3. This dose is practically independent of radiation energy above about 300 kev[3] (5). A density of 3 was selected because a chart constructed for this density combined with the latitude curves makes it simple to determine the maximum thickness that can be radiographed at a particular tube voltage with a sensitivity of 1 per cent. This computation is described in a later paragraph.

[3] Unpublished data of R. Granke, High Voltage Research Laboratory, Electrical Engineering Dept., Massachusetts Institute of Technology.

TABLE II.—TOTAL BEAM ABSORPTION COEFFICIENT AND SCATTERING FACTOR.

Tube Voltage, megavolts	Total Beam Absorption Coefficient for 25 by 25-cm Field, μ, in.$^{-1}$	Calculated Absorption Coefficient of Monochromatic Radiation of Maximum Energy, in.$^{-1}$	Scattering Factor, k, in.$^{-1}$	k/μ
2.....	0.86	0.84	0.80	0.93
3.....	0.75	0.72	0.56	0.75
5.....	0.66	0.62	...	...
6.....	0.61	0.60	0.41	0.67

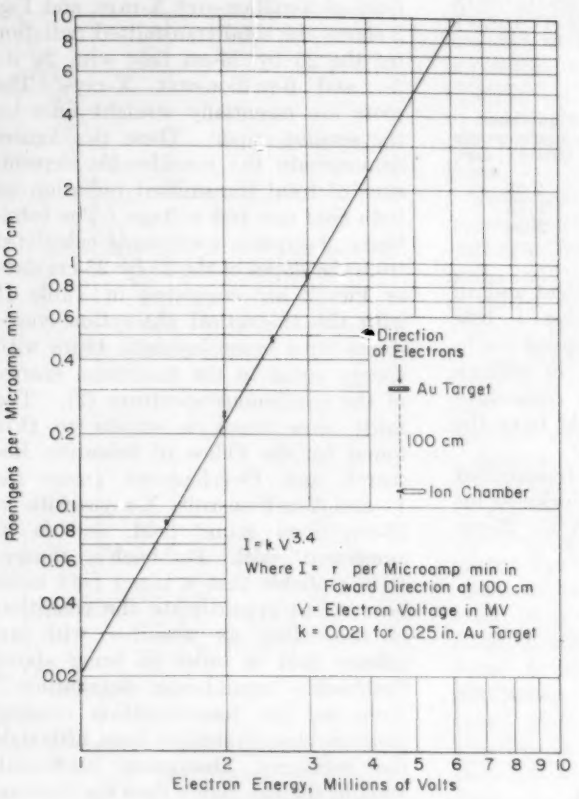
Roentgens per Microamp min at 100 cm
Electron Energy, Millions of Volts
Direction of Electrons
Au Target
100 cm
Ion Chamber
I = k V^3.4
Where I = r per Microamp min in Foward Direction at 100 cm
V = Electron Voltage in MV
k = 0.021 for 0.25 in. Au Target

Fig. 5.—Radiation Output *versus* Electron Energy in megavolts.

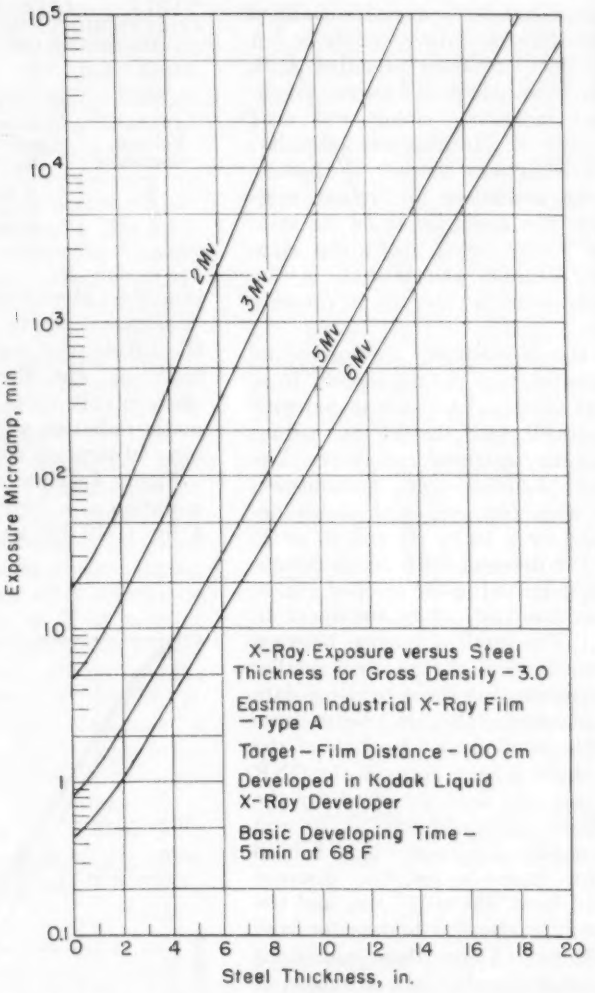
Exposure Microamp, min
Steel Thickness, in.
2Mv
3Mv
5Mv
6Mv
X-Ray Exposure versus Steel Thickness for Gross Density – 3.0
Eastman Industrial X-Ray Film – Type A
Target – Film Distance – 100 cm
Developed in Kodak Liquid X-Ray Developer
Basic Developing Time – 5 min at 68 F

Fig. 6.—Exposure Chart for 2-, 3-, 5-, and 6-megavolt X-rays with Eastman Type A Industrial X-ray Film.

The zero-thickness exposure points on the chart require a knowledge of the output intensity at each voltage. Figure 5 is a plot of output X-ray intensity in roentgens per μa-min at 1 meter as measured on the 3-million-volt X-ray generator. This shows that the output intensity is proportional to the 3.4 power of the voltage in the range from 1 million to 3 million volts. The data were taken with a Victoreen condenser r-meter chamber covered with a Lucite cap thick enough to produce electron equilibrium with the X-radiation. Although absolute measurements of the X-ray output could not be made on the ONR machine because of the lack of knowledge of the actual target current, relative measurements indicated that the 3.4 power of the voltage rule held to the highest voltage. Therefore, the zero thickness points for the two higher voltages were taken from an extrapolation of the curve. From zero thickness up, the exposure curves of Fig. 6 are the inverse of the 25 by 25-cm total-beam transmission plots. If one prefers to use a lower density or a different film, correct exposures can be computed by multiplying the value given on the chart by a constant factor obtained from film-response curves. It should be noted that the exposure curves will apply accurately only with lead intensifying screens of sufficient thickness to produce electron equilibrium with the X-radiation.

Scattering Factor

Calculations of radiographic sensitivity for the various voltages first require determination of the scattering factors. The scattered radiation was found by subtracting the direct from the total radiation for each thickness. The ratio of the scattered to the direct radiation was then plotted against steel thickness for each voltage; the resultant curves in Fig. 7 are approximately linear. The scattering factors, k, for 2-million, 3-million, and 6-million volts, are the slopes of these curves and are listed in Table II. Although there is a 25 per cent difference between the new and the OSRD values of the scattering factor for 2-million-volt X-rays, the expected diminishing improvement with increasing voltage is qualitatively shown. Table II also lists the values of k/μ, a factor often used as an index of radiographic merit as discussed below.

Radiographic Sensitivity

Since sensitivity is the minimum observable thickness variation expressed as a percentage of the total thickness of the absorber, it is desirable to have a low sensitivity. Scattered radiation plays its major rôle in adversely affecting sensitivity. Without scatter, the radiation intensity on a film under an examined object would depend at each point only on the thickness, x, of metal directly above that point. In this idealized situation the sensitivity would be

$$S = \frac{2.3\alpha}{\gamma\mu x} \quad \ldots\ldots\ldots\ldots (2)$$

where:

α = the minimum observable film density difference, usually taken to be 0.008, and

γ = the film gamma or slope of the curve of film density *versus* $\log_{10}$ relative exposure.

Equation 2 indicates that low-voltage X-rays with their correspondingly

higher absorption coefficients would give the best sensitivities. However, scatter cannot be eliminated in practice. Placing the film remote from the absorber or using a moving grid between the absorber and film to block out oblique radiation greatly reduces the scatter to the film but causes a loss of definition and increased exposure and setup time.

The expression for sensitivity, including the effect of scattered radiation (6), is

$$S = \frac{2.3\alpha}{\gamma\mu x}(1 + kx) = \frac{2.3\alpha}{\gamma\mu x}\left(\frac{T}{D}\right) \quad \ldots(3)$$

where:

D = the direct radiation, and
T = the total radiation at depth x.

Thus, sensitivity with scatter is equal to sensitivity without scatter multiplied by the ratio of the total radiation to the direct. If the direct beam could be used free of scatter, the detectable thickness difference would be constant and would depend only on the film contrast and the absorption coefficient. This condition of "absolute sensitivity" is approximately realized for thin sections using extremely high-voltage X-rays.

With large thicknesses, the sensitivity with scatter approaches the constant value

$$S_\infty = \frac{2.3\alpha k}{\gamma\mu} \quad \ldots(4)$$

For this reason the value k/μ has become recognized as an index of the radiographic quality of a beam of X-rays. Qualitatively, k/μ increases with voltage to a maximum at about 0.5 million volt, after which it decreases rapidly at first and then more slowly. Thus, sensitivity actually improves with increasing voltage above 0.5 million volt, and is still improving slowly in the 2- to 6-million-volt region.

Use of the experimental values for the scattering factors in Eq 3 for sensitivity results in the curves shown in Fig. 8. These curves were calculated on the basis of a film gamma of 6 (Eastman Type A film) and α of 0.008. It is clearly shown that the sensitivity for sections thicker than 4 in. is better for 6-million volts than for 3. However, this gain is small compared with that obtained in going from 0.5-million volt to 2-million volts, or even from 2- to 3-million volts.

The sensitivities discussed above are for the ideal case of flat plates. Actual objects to be radiographed vary in shape, and the calculation of the sensitivity can be extremely involved. The alternative form of the sensitivity equation can be used for any point on the radiograph where the ratio of the total to the direct radiation can be determined. A discussion of methods for making approximate calculations of this type is contained in a thesis by Hornbeck (7) as well as in the OSRD report (8). Where very small fields can be used to examine details of objects, it is possible to obtain lower sensitivities because of the resultant decrease in scattered radiation.

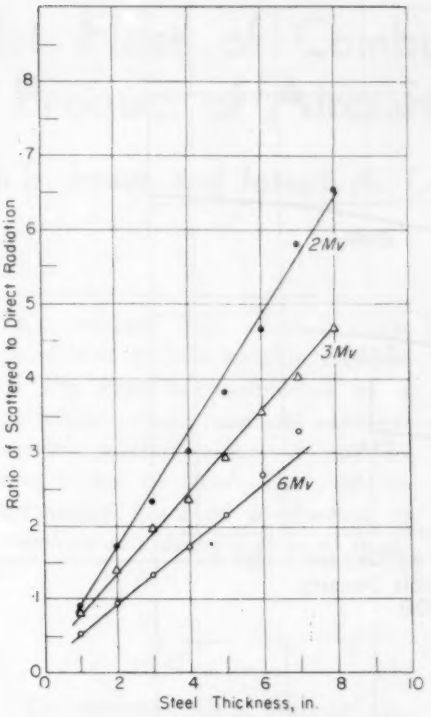

Fig. 7.—Ratio of Scattered-to-Direct Radiation *versus* Steel Thickness for 2-, 3-, and 6-megavolt X-rays.

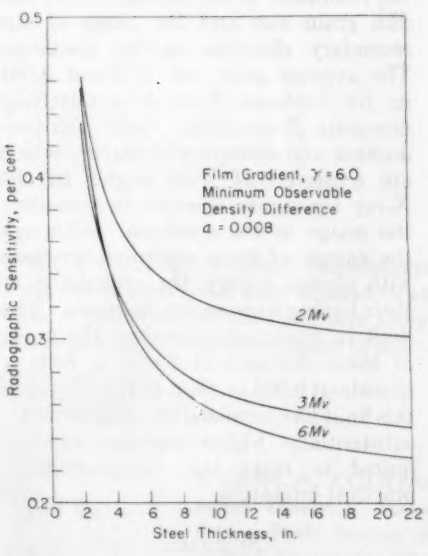

Fig. 8.—Sensitivity *versus* Steel Thickness for 2-, 3-, and 6-megavolt X-rays. 25 by 25-cm Field.

Latitude

Radiographic latitude refers to the thickness range that can be examined with good sensitivity in a single exposure. For steel thicknesses in the straight-line region of the total-beam transmission curves, the following equations hold:

$$\epsilon_{min} = \epsilon_0 e^{-\mu L}$$

$$L = \frac{2.3}{\mu}\left[\log_{10}\epsilon_0 - \log_{10}\epsilon_{min}\right] \quad \ldots(5)$$

where:

ϵ_0 = film exposure to give a density of 3 with a given steel thickness,
ϵ_{min} = film exposure for the minimum film density required to give a sensitivity of 1 per cent, and
L = latitude, defined here as that additional thickness of steel examined with a film density sufficient for a sensitivity of 1 per cent when the given thickness is examined with a density of 3.

The difference expressed in the brackets of Eq 5 can be found for each steel thickness in the following way: The minimum values of film gamma, γ, are calculated by substituting $S = 0.01$ in Eq 3 and solving for different thicknesses. Then the required densities are found from a curve of γ *versus* density for the film used (9). Finally, the difference in log exposure for density 3 and for each minimum density is given by the characteristic curve of the film. This definition of latitude is similar to that adopted by the OSRD group. The selection of a maximum sensitivity of 1 per cent was arbitrary, and the maximum density of 3 was chosen since this is the upper limit of ordinary fluorescent viewers. Although the latitude is certainly increased by the use of greater densities and high-intensity viewers, the present definition is sufficient for a comparison of the latitudes obtained with different tube voltages. The curves of latitude *versus* steel thickness shown in Fig. 9 were obtained by such calculations for type A film.

Maximum Steel Thickness

The maximum steel thickness that can be effectively radiographed in a reasonable time with each tube voltage can be determined by using Fig. 6 in conjunction with Fig. 9. If one assumes a reasonable maximum exposure, Fig. 6 will give for each voltage the steel thickness through which a film density of 3 can be obtained. Adding the latitudes from Fig. 9 to these numbers gives the maximum thicknesses that can be radiographed with a sensitivity of 1 per cent.

If we assume 1.5×10^4 μa-min, or

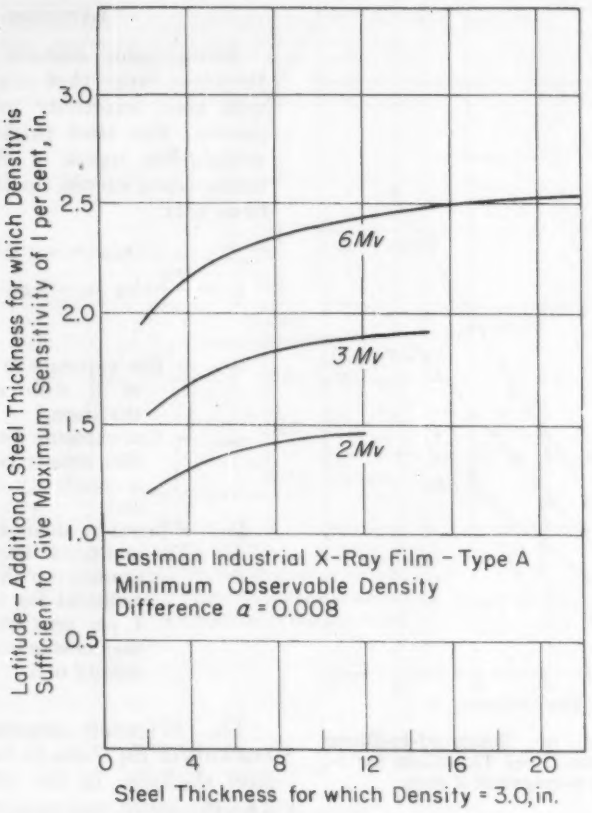

Fig. 9.—Latitude *versus* Steel Thickness for 2-, 3-, and 6-megavolt X-rays. 25 by 25-cm Field.

1 hr at 250 μa, as a practical maximum exposure, the maximum steel thickness is found to be 9.5 in. for 2-million-volt X-rays, 13 in. for 3-million volts, and 20 in. for 6-million volts. These figures are increased somewhat by the use of faster film and shorter target-to-film distance. An example of the gain in speed with voltage is to note that the 20 min required for 7 in. of steel at 2-million volts would be reduced to 2.5 min at 3-million volts, 14 sec at 5-million volts, and 5.5 sec at 6-million volts.

Definition

Definition refers to the sharpness of reproduction on a film of a particular discontinuity in the radiographed object. Simple geometric considerations result in

$$c = \frac{st}{d} \quad \ldots\ldots\ldots\ldots (6)$$

where:

c = the diameter of circle of confusion,
s = the diameter of focal spot,
d = the target-to-defect distance, and
t = the defect-to-film distance.

A dimensionless point in the object will appear as a circle of diameter, c, in the radiograph. For a sharp picture it is important to have a small focal spot and as large a ratio of d/t as is reasonable from the point of view of exposure time. Since the electron beam from a Van de Graaff accelerator is homogeneous in energy, a simple annular magnet around the tube extension can be used to focus the spot to minimum diameters of the order of 0.01 in. (6, p. 61). Other factors beside geometry that ultimately limit the resolution of the radiograph are the film grain size and the range of the secondary electrons in the emulsion. The average grain size is about 0.004 in. for Eastman Type A, a relatively fine-grain X-ray film. Only pair-production and Compton electrons, which are scattered at wide angles to the X-ray beam, are effective in spreading the image in the emulsion. Although the energy of these electrons increases with photon energy, the probability of their having wide angles decreases. The limit in resolution caused by the range of these electrons at 2-million volts is also about 0.004 in. (6, p. 61). Although this limit has increased at 6-million volts, substantially higher voltages are required to make this phenomenon a practical limitation.

Summary

1. The principal radiographic properties of X-rays produced by electrons in the energy range from 2-million to 6-million volts have been investigated for the first time.

2. The expected large increase in radiographic speed and the progressively smaller improvement in sensitivity as the voltage is increased from 2-million to 6-million volts are experimentally confirmed.

3. It is evident that a nearly optimum balance of radiographic properties for the investigation of thick metal sections is found in the energy range from 2 million to 6 million volts. Further substantial increases in X-ray voltage would result in increased range of secondary electrons, a diminution of available field size, and a slow increase of absorption coefficient due to pair-production.

Acknowledgment:

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(3) *OSRD Report No. 4488*, Vol. 4, Ch. 3*c* (1945).
(4) *OSRD Report No. 4488*, Vol. 4, Ch. 3*b* (1945).
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(8) *OSRD Report No. 4488*, Vol. 4, Ch. 4*e* (1945).
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Relation Between Net Heat of Combustion and Aniline-Gravity Product of Aircraft Fuels*

By Ralph S. Jessup and Joseph A. Cogliano

Tests indicate that, while it is not possible to make a reliable estimate of the heat of combustion of a petroleum fuel from its aniline-gravity product alone, it appears that it can be used as a guide in estimating heats of combustion of members of a definite class of fuels.

THE work described in this paper was undertaken at the request of the Bureau of Aeronautics of the Department of the Navy, in order to determine the feasibility of extending to JP-4 and JP-5 fuels the relations between net heat of combustion and aniline-gravity product previously found by Jessup and Cragoe (1)[1] and by Rothberg and Jessup (2) to hold for AN-F-28 and AN-F-58 aircraft fuels.

Fuels Investigated

The 36 fuel samples investigated were submitted by individual refiners. Arrangements for selecting the fuel samples and having them delivered to the National Bureau of Standards were made by the Bureau of Aeronautics of the Department of the Navy. The fuels were selected to cover as wide as possible a range of properties likely to be significantly related to heat of combustion, such as aniline point, gravity, etc.

The producers of the fuels investigated and the number of samples supplied by each are listed below.

Producer	Type of Fuel	Number of Samples
Phillips Petroleum Co.	JP-4 and JP-5	4
Shell Oil Co.	JP-4, No. 1 fuel oil	5
Socony-Vacuum Oil Co.	JP-4	6
Standard Oil of California (Calif. Research Corp.)	JP-4, JP-5	2
Standard Oil Development Co. (Esso Laboratories)	JP-5	6
Standard Oil Co. of Indiana (Whiting Laboratories)	JP-4, JP-5, No. 1 fuel oil	3
Texas Company	JP-4, No. 1 fuel oil	4
Tide Water Associated Oil Co.	JP-4, JP-5	2
Unspecified	Esso Aruba diesel fuel, Fischer-Tropsch, 29-cetane fuel, Navy spec. 7-0-2e	4

Unit of Heat

The measurements of heats of combustion were made in terms of the absolute joule as the unit of energy, and the results were initially expressed in absolute joules per gram weight of fuel in air against brass weights. Conversion to British thermal units per pound weight in air was made by means of the factor:

1 absolute joule per gram = 0.429917 Btu per pound

The British thermal unit so defined is the unit used in all modern steam tables.[2]

Apparatus and Method

The aniline points[3] of the fuels were determined in accordance with ASTM Method D 611–41 T,[4] API gravities[3] in accordance with ASTM Method D 287–39,[5] and sulfur contents[3] by ASTM Method D 129–44.[6] The carbon and hydrogen contents[3] were determined by microcombustion analysis, all weights being reduced to vacuum.

The bomb calorimeter, accessory apparatus, and the method of calculating results on gross heat of combustion have been described (4). Thin-walled glass bulbs of the type previously described (1,5,6) were used to contain the liquid samples. The method of

[3] Aniline points, API gravities, and sulfur contents were determined by J. A. Walker; hydrogen and carbon contents by R. A. Paulson, both of the National Bureau of Standards.

[4] Tentative Method of Test for Aniline Point of Petroleum Products (D 611–41 T), 1941 Supplement to Book of ASTM Standards, Part III, p. 257.

[5] Standard Method of Test for Gravity of Petroleum and Petroleum Products by Means of the Hydrometer (D 287–39), 1949 Book of ASTM Standards, Part 5, p. 859.

[6] Standard Method of Test for Sulfur in Petroleum Oils by Bomb Method (D 129–44), 1946 Book of ASTM Standards, Part III-A, p. 284.

RALPH S. JESSUP, Physicist, Thermodynamics Section, National Bureau of Standards, has been engaged in accurate measurements of heats of combustion of fuels and pure compounds for many years. He is the author of numerous papers in this field.

JOSEPH A. COGLIANO, Research Associate, George Washington University, formerly in the Thermodynamics Section and Engine Fuels Section of the National Bureau of Standards, has worked on various problems connected with liquid hydrocarbon fuels, and is the author of a number of papers and reports in this field.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

* This work was supported by the Bureau of Aeronautics of the Department of the Navy.

[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

[2] This expression was derived from the original definition of the I.T. calorie as 1/860 international watt hour (3), the relations between the absolute and international electrical units (12), and the definition of the British thermal unit by the relation 1 I.T. calorie per gram = 1.8 Btu per lb.

filling the bulbs has been discussed previously (2).

The gross heat of combustion at constant volume, Q_v(gross), was measured at 28 C, Q_v(gross) being here defined as the heat liberated when unit weight of the fuel is burned in a constant volume bomb, the products of combustion being gaseous carbon dioxide, gaseous sulfur dioxide, and liquid water. In order to permit comparison of the results with data on pure hydrocarbons, most of which are referred to 25 C, the values of Q_v(gross) at 25 C were calculated from the observed values at 28 C, using the method described previously (2).

Calibration of Calorimeter

The calorimeter was calibrated with Standard Sample 39g of benzoic acid, using the value 26433.8 absolute joules per gram mass (weight in vacuum) (**7,8,9**) for the heat of combustion of this substance under the standard conditions of the bomb process. Two series of calibration experiments were made on slightly different calorimetric systems. The standard deviation of the mean of the results of the calibration experiments was calculated to be 0.019 per cent of the energy equivalent of the calorimeter for the first series of experiments and 0.016 per cent for the second series.

Test Results

Experimental Data:

Table I gives values of API gravity, aniline point, hydrogen, carbon, and sulfur contents, observed gross heat of combustion [Q_v (gross)], and observed net heat of combustion [Q_p(net)] for the 36 fuels investigated, together with values calculated from the aniline-gravity product and from the hydrogen content.

Equation 1 of reference **1**:

$$Q_p\,(\text{net}) = Q_v\,(\text{gross}) - 91.23\,(\%\ \text{H}) \quad \ldots(1)$$

was used to calculate Q_p(net) from Q_v(gross) measured calorimetrically. Equation 1 corresponds to the definition of Q_p(net) as the heat liberated when unit weight of the fuel is burned at a constant pressure of one atmosphere, the products of combustion being gaseous carbon dioxide, gaseous water, and a gaseous sulfur dioxide. Each value of gross heat of combustion in Table I is the mean of two or more determinations which usually agreed within less than 0.10 per cent, although in a few cases the difference was larger, the maximum difference being about 0.15 per cent. The average deviation of the individual results from the means was 0.02 per cent with a maximum average deviation for a single fuel of 0.05 per cent.

The final experimental values of Q_p (net) have been reduced to a sulfur-free basis by means of the relation:

$$Q_p\,(\text{net})_{\text{S-free}} = \frac{Q_p\,(\text{net})_{\text{obs.}} - 43.7\,(\%\ \text{S})}{1 - 0.01\,(\%\ \text{S})} \quad \ldots(2)$$

where (% S) represents the weight percentage of sulfur in the fuel. The factor 43.7 was calculated using recent data (**10,11**) on the thermochemistry of sulfur compounds.

Relation Between Q_p (net) and the Aniline-Gravity Product:

On the basis of previous experience (2), it was expected that a single relation expressing Q_p (net) as a function of aniline-gravity product, A × G, would satisfactorily represent the data of the present investigation as well as data reported in references **1** and **2**, and the following equation was derived by the method of least squares from the results, all reduced to a sulfur-free basis, of all three of these investigations:

$$Q_p\,(\text{net}) = 17608.175 + 0.205382\,(\text{A} \times \text{G}) - 7.245 \times 10^{-6}\,(\text{A} \times \text{G})^2 \quad \ldots(3)$$[7]

Further examination of the data, however, showed that there were systematic differences between the different types of fuel with respect to the relation between Q_p (net) and A × G. For this reason separate linear equations were derived by the method of least squares to represent the data on each of the four types of fuels: AN-F-28, AN-F-58, JP-4, and JP-5. It was found, however, that the slopes of the four equations were not significantly different and that the intercepts for the AN-F-28 and AN-F-58 fuels were also not significantly different, so that the data on all four types of fuels can be satisfactorily represented by three linear equations, all having the same slope. These three equations appear at the bottom of this page.

In deriving Eqs 5 and 6, the data on fuels Nos. 1, 2, 4, 5, 6, 8, 22, and 23 were omitted. Fuels Nos. 1, 2, 4, and 5 are those listed as unspecified with respect to source in the tabulation of fuels investigated, given previously in this paper. These fuels do not satisfy the specified requirements for any of the four classes of fuels under consideration. It may be noted that two of these four fuels (Nos. 1 and 4) are largely responsible for the departure of Eq 3 from linearity. Fuels Nos. 6, 8, 22, and 23 were submitted as approximating JP-5 fuels, but were actually classified as No. 1 fuel oils. The results for these four fuels agree with Eq 6 about as well as the results for the JP-5 fuels on which this equation is based.

All observed values of net heat of combustion obtained in the present investigation may be compared with values calculated from Eq 3, and the values for JP-4 and JP-5 fuels may be compared with values calculated from Eqs 5 and 6, respectively, in Table I. It will be seen that the agreement with Eqs 5 and 6 is better for these two types of fuel than the agreement with Eq 3. It will be seen also that the experimental results for fuels Nos. 1, 2, 4, and 5, which do not satisfy the specified requirements for either JP-4 or JP-5 fuels, differ from results calculated from Eq 6 by considerably larger amounts than the results for JP-5 fuels and the No. 1 fuel oils. The results for JP-4, JP-5, and No. 1 fuel oils are shown graphically in Fig. 1. The straight lines in this figure represent Eqs 5 and 6. A similar graph for AN-F-28 and AN-F-58 fuels will be found in reference 2.

As indicated previously, Eqs 4, 5, and 6 represent data which have been reduced to the basis that the fuels are free from sulfur. If it is desired to use these equations to estimate the net heat of combustion of a fuel containing sulfur,

[7] The authors are indebted to the Statistical Engineering Laboratory of the National Bureau of Standards for the derivation of Eqs 3, 4, 5, and 6, and for the statistical analysis of the data.

Fuel Type	Number of Observations	Equation	Equation Number	Standard Deviation			Range of (A × G) in Which Equation Is Applicable
				Single Determination	Intercept	Slope	
AN-F-28 } AN-F-58 }	89[a]	Q_p (net) = 17 940 + 0.1056 (A × G)	(4)	28	17	0.0023	4000 to 10 000
JP-4	17	Q_p (net) = 17 977 + 0.1056 (A × G)	(5)	19	15	0.0023	5000 to 8 000
JP-5	11	Q_p (net) = 17 914 + 0.1056 (A × G)	(6)	30	15	0.0023	4000 to 7 000

[a] These data are from references 1 and 2.

TABLE I.—RESULTS OF MEASUREMENTS ON 36 FUELS.

Fuel Type	Fuel No.	Hydrogen, per cent	Carbon, per cent	Sulfur, per cent	Aniline Point, deg Fahr	Gravity, deg API	Aniline-Gravity Product	Observed Heat of Combustion at 25 C			Calculated Heat of Combustion at 25 C		
								Q_v (gross), Btu per lb	Q_p (net)		From Aniline-Gravity Product, Btu per lb		From Hydrogen, Btu per lb[a]
									Experimental Value, Btu per lb	Corrected to S-free Basis, Btu per lb			
											Eq 3	Eq 5	
JP-4	3	14.7	85.3	0.013	130.5	54.7	7138	20 068	18 727	18 729	18 705	18 731	18 805
	7	14.0	85.6	0.171	129.7	45.2	5862	19 815	18 538	18 562	18 563	18 596	18 641
	9	14.3	85.7	0.115	126.1	53.5	6746	19 988	18 683	18 700	18 664	18 689	18 711
	10	14.4	85.6	0.122	135.0	52.9	7142	20 035	18 721	18 739	18 705	18 731	18 735
	11	14.5	85.5	0.045	138.9	53.4	7417	20 088	18 766	18 772	18 733	18 760	18 758
	12	14.5	85.5	0.109	136.9	54.7	7488	20 083	18 760	18 776	18 740	18 768	18 758
	13	14.1	85.8	0.092	129.0	50.2	6476	19 921	18 635	18 648	18 634	18 661	18 664
	24	13.6	86.3	0.235	108.5	48.9	5306	19 785	18 544	18 578	18 494	18 537	18 547
	25	13.9	86.2	0.207	129.2	45.0	5814	19 818	18 550	18 579	18 557	18 591	18 618
	26	13.8	85.9	0.372	116.1	46.5	5399	19 775	18 516	18 569	18 506	18 547	18 594
	28	13.5	86.4	0.132	128.5	40.1	5153	19 703	18 471	18 490	18 474	18 521	18 524
	30	13.9	86.1	0.164	125.8	47.0	5913	19 866	18 598	18 621	18 569	18 601	18 618
	31	14.3	85.5	0.064	136.0	51.3	6977	20 011	18 707	18 716	18 688	18 714	18 711
	32	14.2	85.7	0.103	134.4	52.6	7069	19 992	18 696	18 711	18 698	18 723	18 688
	33	13.9	86.1	0.110	121.1	49.9	6043	19 870	18 602	18 617	18 585	18 615	18 618
	34	13.3	86.4	0.224	112.6	44.4	4999	19 681	18 468	18 500	18 454	18 505	18 477
	35	13.6	86.3	0.085	116.2	48.3	5612	19 788	18 547	18 559	18 533	18 570	18 547
											Eq 3	Eq 6	
JP-5	14	13.2	86.9	0.106	129.9	33.8	4391	19 582	18 377	18 392	18 370	18 378	18 454
	15	14.0	86.0	0.125	144.1	43.3	6240	19 856	18 579	18 597	18 608	18 573	18 641
	16	12.7	87.4	0.088	128.8	34.3	4418	19 447	18 288	18 301	18 374	18 381	18 337
	17	14.0	85.9	0.112	148.5	43.0	6386	19 850	18 572	18 588	18 624	18 588	18 641
	18	13.3	86.8	0.026	120.9	36.2	4377	19 606	18 393	18 396	18 368	18 376	18 477
	19	12.9	86.9	0.072	127.6	31.8	4058	19 476	18 300	18 310	18 322	18 343	18 384
	20	13.4	86.5	0.048	139.8	38.3	5354	19 692	18 469	18 476	18 500	18 479	18 501
	21	13.2	86.9	0.068	131.4	36.9	4849	19 634	18 430	18 439	18 434	18 426	18 454
	27	13.3	86.4	0.447	128.1	36.8	4714	19 578	18 365	18 428	18 415	18 412	18 477
	29	13.1	86.7	0.154	130.8	32.0	4186	19 536	18 341	18 363	18 341	18 356	18 430
	36	13.8	86.2	0.076	150.8	42.2	6364	19 854	18 595	18 606	18 622	18 586	18 594
											Eq 3	Eq 6	
No. 1 fuel oils	6	13.8	86.2	0.212	145.0	40.6	5887	19 735	18 476	18 506	18 566	18 536	18 594
	8	13.4	86.4	0.221	132.8	39.0	5179	19 637	18 415	18 446	18 478	18 461	18 501
	22	13.8	86.3	0.134	147.2	41.9	6168	19 804	18 546	18 565	18 599	18 565	18 594
	23	13.9	86.1	0.106	148.3	42.9	6362	19 868	18 600	18 615	18 622	18 586	18 618
											Eq 3	Eq 6	
Miscellaneous	1	15.2	84.7	0.116	186.4	51.9	9674	20 165	18 779	18 795	18 917	18 936	18 921
	2	13.9	85.9	0.350	156.4	38.0	5943	19 682	18 414	18 464	18 573	18 542	18 617
	4	11.9	88.0	0.066	106.5	26.5	2822	19 092	18 006	18 015	18 130	18 212	18 150
	5	13.5	86.3	0.053	155.7	37.3	5808	19 673	18 441	18 449	18 557	18 527	18 524

[a] Calculated from Eq 4 of *Technical Note No. 996*, Nat. Advisory Comm. Aeronautics: Q_p (net) = 15365 + 234 (% H).

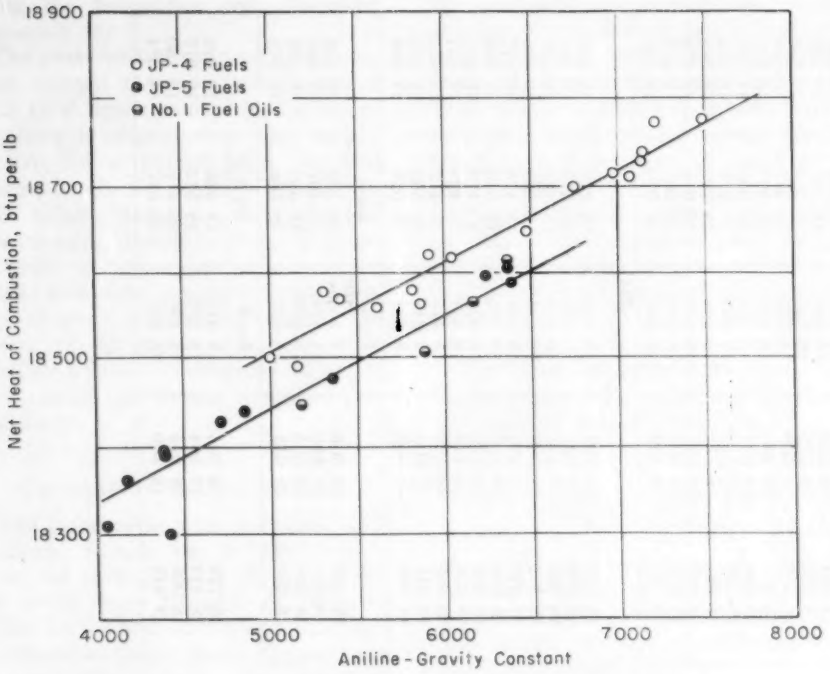

Fig. 1.—Results Obtained on JP-4, JP-5, and No. 1 Fuel Oils.

$Q_p(\text{net})_S$, the value calculated from the appropriate one of these equations ($Q_p(\text{net})_{S\text{-free}}$) may be substituted in the following equation:

$$Q_p(\text{net})_S = [1 - 0.01\ (\%\ S)]\ Q_p(\text{net})_{S\text{-free}} + 43.7\ (\%\ S) \quad \ldots(2a)$$

which is equivalent to Eq 2.

Comparison of Results of Various Investigations

Comparisons of observed and calculated results of the present investigation and various previous ones are shown graphically in Figs. 2 to 8, inclusive, where the ordinates represent deviations, in British thermal units per pound, of observed values of $Q_p(\text{net})$ from values calculated from the linear equation:

$$Q_p(\text{net}) = 17944.9 + 0.1043\ (A \times G) \quad \ldots(7)$$

which is Eq 7 of reference 2. The curves shown in these figures represent deviations from Eq 7 of various other equations which have been proposed to represent net heat of combustion as functions of aniline-gravity product, as follows:

A. Equation 3 of this paper.

B. The quadratic equation:

$$Q_p(\text{net}) = 17747.9 + 0.1782\ (A \times G) - 5.347 \times 10^{-6}\ (A \times G)^2$$

which is Eq 2 given in a Texas Company report (**12**) to represent data on various hydrocarbon fuels, including data on pure compounds.

C. The fourth degree equation:

$$Q_p(\text{net}) = 17145.9 + 0.51959\ (A \times G) - 0.69113 \times 10^{-4}\ (A \times G)^2 + 0.47772 \times 10^{-8}\ (A \times G)^3 - 0.1235 \times 10^{-12}\ (A \times G)^4$$

used by Fein, Wilson, and Sherman (**13**) to represent data on various hydrocarbon fuels and pure compounds, including those given in the Texas Company report (**12**).

D. The quadratic equation:

$$Q_p(\text{net}) = 17737 + 0.159\ (A \times G) - 3.55 \times 10^{-6}\ (A \times G)^2$$

given by Rickles (**14**) to represent his data on a number of diesel fuels, together with the data given in references **1** and **2**, all reduced to a sulfur-free basis.

E. Equation 5 of this paper for JP-4 fuels.

F. Equation 6 of this paper for JP-5 fuels.

Equation 4 of this paper is not shown in the figures. It would be represented by a straight line running from 1 Btu per lb below the base line at $A \times G = 3000$ to 8 Btu per lb above the base line at $A \times G = 10{,}000$.

The data of the present investigation are shown in Fig. 2, and the data of references **1** and **2** are shown in Fig. 3.

In Figs. 4 to 8, inclusive, are shown deviations from Eq 7 of data reported by other laboratories on various hydrocarbon fuels. All of these results have been reduced to a sulfur-free basis. The data shown in Figs. 4 and 5 represent results on miscellaneous fuels and on pure hydrocarbons, respectively, which were taken from a Texas Company report (**12**) issued in 1951. The data shown in Fig. 6 represent results on gasolines that were given in U. S. Bureau of Mines reports (**15,16**) as having been obtained in various commercial laboratories in 1949 and 1950. The data on diesel fuels shown in Fig. 7 were taken from an Esso Laboratories report by Rickles (**14**). The data on miscellaneous distillates shown in Fig. 8 were obtained in U. S. Bureau of Mines laboratories. The samples were prepared and analyzed at the Bureau of Mines Petroleum Experiment Station in Bartlesville, Okla., and the measure-

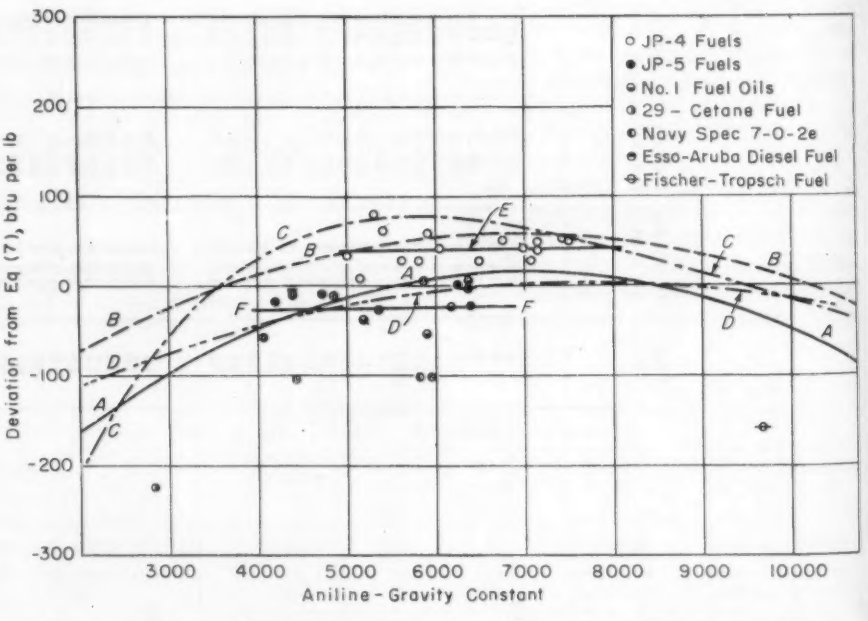

Fig. 2.—Deviations from Eq 7 of Experimental Results of This Investigation.

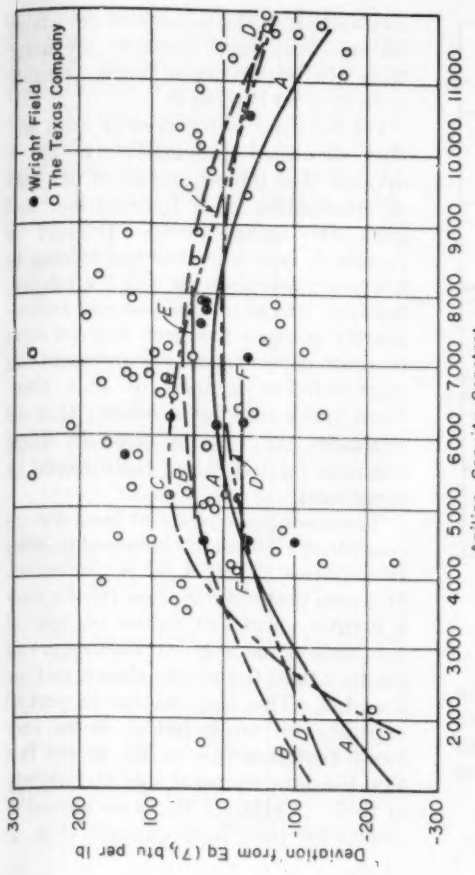

Fig. 4.—Deviations from Eq 7 of Data on Fuels in Texas Company Report.

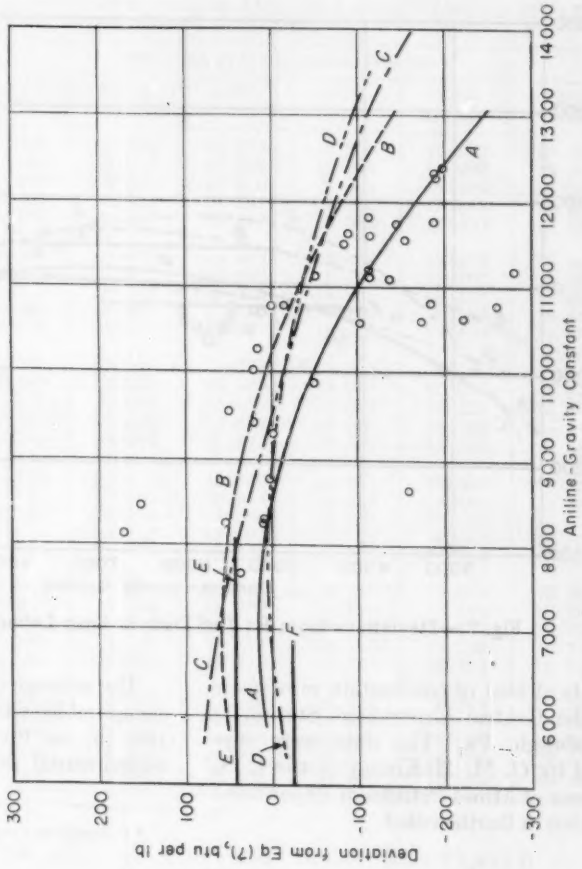

Fig. 6.—Deviations from Eq 7 of Data in U. S. Bureau of Mines Reports.

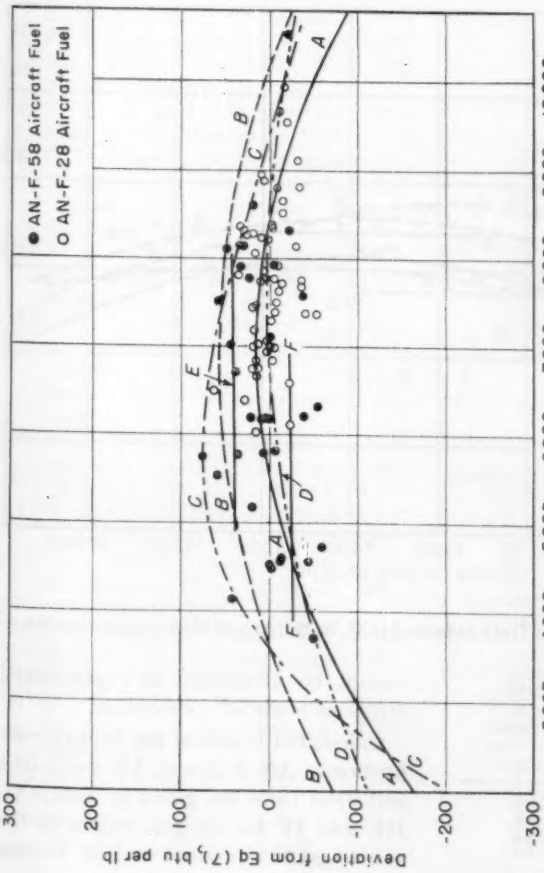

Fig. 3.—Deviations from Eq 7 of Experimental Results Given in References 1 and 2.

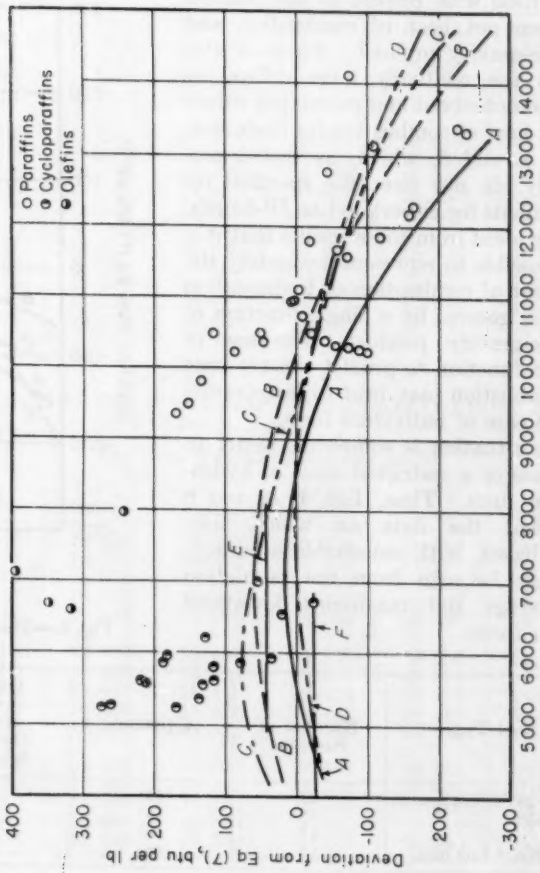

Fig. 5.—Deviations from Eq 7 of Data on Pure Hydrocarbons in Texas Company Report.

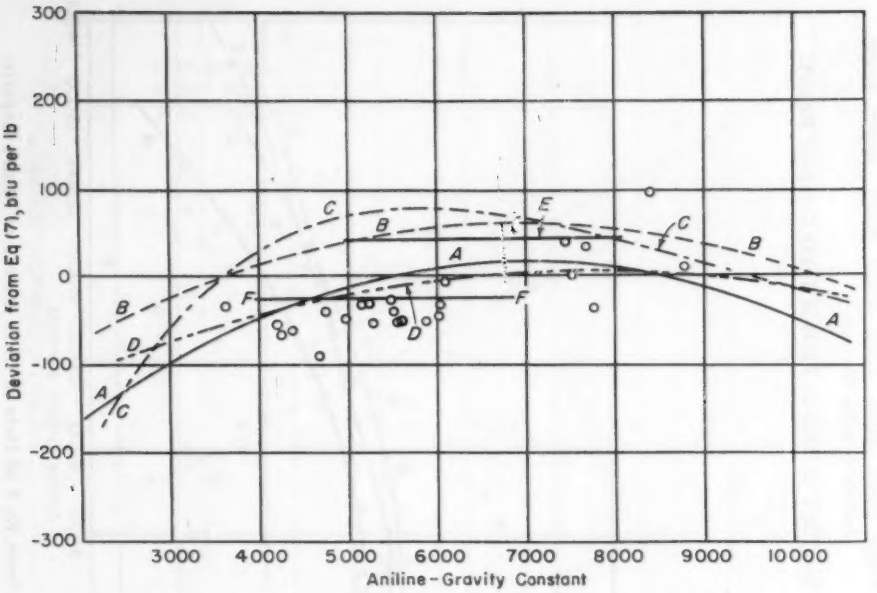

Fig. 7.—Deviations from Eq 7 of Data in Esso Laboratories Report.

ments of heat of combustion were made at the Central Experiment Station in Pittsburgh, Pa. The data were supplied by C. M. McKinney of the U. S. Bureau of Mines Petroleum Experiment Station in Bartlesville.[3]

The average deviations are seen to be comparable with the accuracy (18 Btu per lb, or 0.1 per cent) of a good experimental determination of heat of combustion. The maximum deviations for individual fuels, however, are larger than the experimental error, ranging from 40 to 80 Btu per lb.

On the basis of the present work and that described previously (**1**, **2**), it appears that the estimation of net heat of combustion of a hydrocarbon fuel from its aniline-gravity product is justifiable only when the fuel belongs to a well-defined class for which a relation between heat of combustion and aniline-gravity product has been derived from accurate experimental measurements on representative samples of that class. Even in this case the possibility that the estimates may be in error by large amounts for individual fuels should be recognized.

These conclusions are at least not inconsistent with results obtained in other laboratories (Figs. 4 to 8, inclusive). It is seen that some of these results show a greater spread in values of heat of combustion for a given aniline-gravity product than the results shown in Figs. 2 and 3. This may be due in part to experimental error, but it seems very likely that it is due partly to the fact that the data represent a greater variety of fuels. Certainly the wide spread of results for pure hydrocarbons (Fig. 4) cannot be attributed to experimental errors in heats of combustion.

[3] Private communication, August 4, 1953.

Discussion

Figures 1 and 2 show clearly the systematic difference between JP-4 and JP-5 fuels with respect to the relation between net heat of combustion and aniline-gravity product. Figure 2 also shows the relatively large differences between observed and calculated values of net heat of combustion for fuels Nos. 1, 2, 4, and 5, which, as stated previously, do not meet the specified requirements for either JP-4 or JP-5 fuels. It is evident from these results that it is not possible to represent accurately the net heat of combustion of hydrocarbon fuels in general by a single function of aniline-gravity product. The use of such a function to predict the net heat of combustion may lead to large errors in the case of individual fuels.

The situation is somewhat better in the case of a restricted class of hydrocarbon fuels. Thus, Eqs 4, 5, and 6 represent the data on which they were based, with reasonable accuracy, as may be seen from the tabulation of average and maximum deviations shown above.

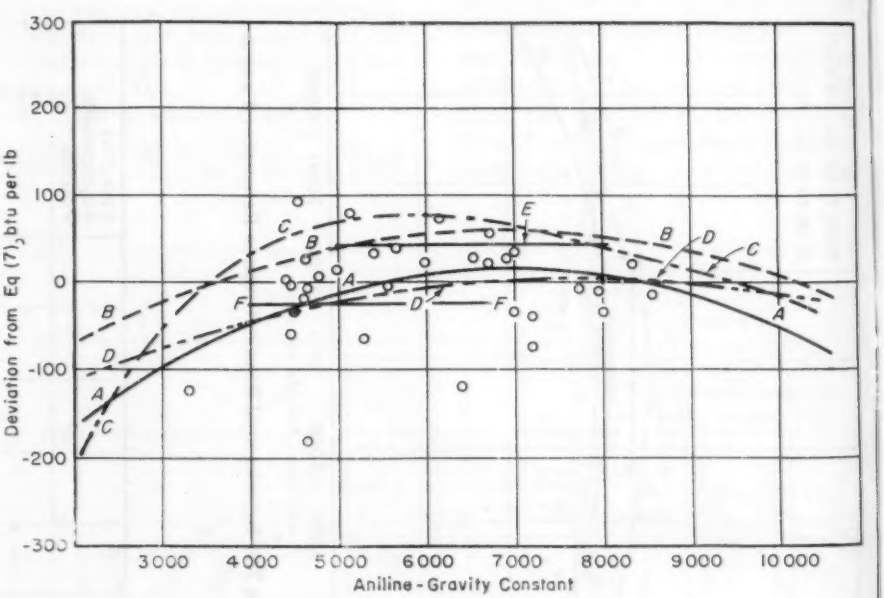

Fig. 8.—Deviations from Eq 7 of Data obtained in U. S. Bureau of Mines Laboratories.

Fuel Type	Number of Samples	Equation	Observed minus Calculated	
			Average Deviation, Btu per lb	Maximum Deviation, Btu per lb
AN-F-28	57	(4)	±18	+64
AN-F-58	32	(4)	±30	−64
JP-4	17	(5)	±14	+41
JP-5, No. 1 fuel oils	15	(6)	±20	−80

Calculated values of net heat of combustion of AN-F-28 and AN-F-58, JP-4 and JP-5 fuels are given in Tables II, III, and IV for integral values of the aniline-gravity product and for various

sulfur contents. Because of possible differences in composition between the AN-F-28 gasoline samples used in the measurements described in reference **1** and 100/130 gasolines representative of current production, there may be some question as to the applicability of Eq 4 and Table II to the latter class of fuels.

TABLE II.—VALUES OF Q_p(NET) FOR AN-F-28 AND AN-F-58 FUELS CALCULATED FROM EQS 4 AND 2*a*.

Aniline-Gravity Product	Net Heat of Combustion, Btu per lb					
	0% Sulfur	0.2% Sulfur	0.4% Sulfur	0.6% Sulfur	0.8% Sulfur	1.0% Sulfur
4 200	18 384	18 356	18 328	18 300	18 272	18 244
4 400	18 405	18 377	18 349	18 321	18 293	18 265
4 600	18 426	18 398	18 370	18 342	18 314	18 285
4 800	18 447	18 419	18 391	18 363	18 334	18 306
5 000	18 468	18 440	18 412	18 383	18 355	18 327
5 200	18 489	18 461	18 433	18 404	18 376	18 348
5 400	18 510	18 482	18 453	18 425	18 397	18 369
5 600	18 531	18 503	18 474	18 446	18 418	18 389
5 800	18 552	18 524	18 495	18 467	18 439	18 410
6 000	18 574	18 546	18 517	18 489	18 460	18 432
6 200	18 595	18 567	18 538	18 510	18 481	18 453
6 400	18 616	18 588	18 559	18 531	18 502	18 474
6 600	18 637	18 608	18 580	18 552	18 523	18 494
6 800	18 658	18 629	18 601	18 573	18 544	18 515
7 000	18 679	18 650	18 622	18 593	18 565	18 536
7 200	18 700	18 671	18 643	18 614	18 585	18 557
7 400	18 721	18 692	18 664	18 635	18 606	18 578
7 600	18 743	18 714	18 686	18 657	18 628	18 599
7 800	18 764	18 735	18 707	18 678	18 649	18 620
8 000	18 784	18 755	18 726	18 698	18 669	18 640
8 200	18 806	18 777	18 748	18 719	18 691	18 662
8 400	18 827	18 798	18 769	18 740	18 711	18 682
8 600	18 848	18 819	18 790	18 761	18 732	18 703
8 800	18 869	18 840	18 811	18 782	18 753	18 724
9 000	18 890	18 861	18 832	18 803	18 774	18 745
9 200	18 912	18 883	18 854	18 825	18 796	18 767
9 400	18 933	18 904	18 875	18 846	18 816	18 787
9 600	18 954	18 925	18 896	18 866	18 837	18 808
9 800	18 975	18 946	18 917	18 887	18 858	18 829
10 000	18 996	18 967	18 937	18 908	18 879	18 850

TABLE III.—VALUES OF Q_p(NET) FOR JP-4 FUELS CALCULATED FROM EQS 5 AND 2*a*.

Aniline-Gravity Product	Net Heat of Combustion, Btu per lb					
	0% Sulfur	0.2% Sulfur	0.4% Sulfur	0.6% Sulfur	0.8% Sulfur	1.0% Sulfur
5200	18 526	18 498	18 469	18 441	18 413	18 384
5400	18 547	18 519	18 490	18 462	18 434	18 405
5600	18 568	18 540	18 511	18 483	18 454	18 426
5800	18 589	18 561	18 532	18 504	18 475	18 447
6000	18 611	18 583	18 554	18 526	18 497	18 469
6200	18 632	18 603	18 575	18 547	18 518	18 489
6400	18 653	18 624	18 596	18 568	18 539	18 510
6600	18 674	18 645	18 617	18 588	18 560	18 531
6800	18 695	18 666	18 638	18 609	18 580	18 552
7000	18 716	18 687	18 659	18 630	18 601	18 573
7200	18 737	18 708	18 680	18 651	18 622	18 593
7400	18 758	18 729	18 700	18 672	18 643	18 614
7600	18 779	18 750	18 721	18 693	18 664	18 635
7800	18 800	18 771	18 742	18 714	18 685	18 656
8000	18 821	18 792	18 763	18 735	18 706	18 677

TABLE IV.—VALUES OF Q_p(NET) FOR JP-5 FUELS CALCULATED FROM EQS 6 AND 2*a*.

Aniline-Gravity Product	Net Heat of Combustion, Btu per lb					
	0% Sulfur	0.2% Sulfur	0.4% Sulfur	0.6% Sulfur	0.8% Sulfur	1.0% Sulfur
4200	18 358	18 330	18 302	18 274	18 246	18 218
4400	18 379	18 351	18 323	18 295	18 267	18 239
4600	18 400	18 372	18 344	18 316	18 288	18 260
4800	18 421	18 393	18 365	18 337	18 309	18 280
5000	18 442	18 414	18 386	18 358	18 329	18 301
5200	18 463	18 435	18 407	18 378	18 350	18 322
5400	18 484	18 456	18 428	18 299	18 371	18 343
5600	18 505	18 477	18 448	18 420	18 392	18 364
5800	18 526	18 498	18 469	18 441	18 413	18 384
6000	18 548	18 520	18 491	18 463	18 435	18 406
6200	18 569	18 541	18 512	18 484	18 455	18 427
6400	18 590	18 562	18 533	18 505	18 476	18 448
6600	18 611	18 583	18 554	18 526	18 498	18 469
6800	18 632	18 604	18 575	18 547	18 519	18 490
7000	18 653	18 625	18 596	18 568	18 540	18 511

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(1) R. S. Jessup and C. S. Cragoe, *Technical Note No. 996*, Nat. Advisory Comm. Aeronautics, June, 1945.

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(15) O. C. Blade, Bureau of Mines Reports of Investigations 4664, March, 1950.

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(17) Specification Mil-F-5624 B, December 7, 1953.

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A Note on the Oxyquinolate Determination of Magnesium Oxide in Cement

By Leonard Bean and Nancy J. Tucker

Two simple modifications of the ASTM alternate method for determining MgO reduce the time required without sacrifice of accuracy. When a calcium determination is not required, the volume at which the calcium oxalate is precipitated may be left at 300 ml and a 15-min steam bath digestion substituted for the 1-hr standing period.

THE latest alternate ASTM Method (C. 114 – 53)[1] and alternate Federal Specification Method[2] for determining magnesium oxide in portland cement are time consuming. After the precipitation of calcium oxalate, the present directions require the solution to stand 1 hr. Then the solution must be reheated to 70 C before 8-hydroxyquinoline is added and the solution made ammoniacal in order to precipitate the magnesium oxyquinolate.

The precipitation of calcium oxalate by addition of ammonium oxalate to an acid solution, heating to 70 C, making the solution ammoniacal, and then allowing to stand for 1 hr has been shown to give better results than the precipitation by adding ammonium oxalate to a boiling ammoniacal solution.[3, 4] For that reason, in the latest ASTM and Government methods, the 1-hr standing period was also included for the precipitation of calcium oxalate when magnesium oxyquinolate is to be precipitated in the presence of the calcium oxalate. Redmond had shown that the calcium oxalate need not be filtered off when only magnesium oxide is being determined.[5,6] As far as is known, no one has previously determined whether this 1-hr standing period is necessary under the conditions specified in the ASTM and Federal specifications. While studying this point in the Analytical Laboratory, Concreting Materials Section of the National Bureau of Standards, it was decided also to determine whether the evaporation to 200 ml before the calcium oxalate precipitation is necessary when magnesium oxide only is being determined. Ordinarily the combined filtrates and washings following the removal of the ammonium hydroxide group by a double precipitation amount to about 300 ml. If this evaporation could be dispensed with, the magnesium oxide determination could be further speeded up.

First, the effects of substituting 15-min and 30-min standing on a steam bath for the 1-hr standing period at room temperature were tried. No significant differences in results were obtained for MgO as compared with the present ASTM and Federal Methods. Then the effect of increasing the volume for the calcium oxalate precipitation from 200 to 300 ml was studied. Again no significant differences in results for MgO were obtained. Finally, Table I gives the combined effects on the MgO determination of reducing the time and increasing the volume for the calcium oxalate precipitation. A study of these results shows that practically identical results are obtained for MgO by leaving the volume at 300 ml and allowing the calcium oxalate to stand on a steam bath for 15 min as by the present ASTM and Federal specification methods. Steam bath digestion obviates the need to reheat to 70 C. It is estimated that the modified procedure shortens the time required to determine the magnesium oxide in six samples of cement by 1½ to 2 hr.

Appropriate changes in the wording of the alternate procedure for magnesium oxide determination are, in consequence of the findings just described, being recommended to the appropriate committees of the Federal Specification Board and the ASTM for their consideration in future revisions of this method.

TABLE I.—COMBINED EFFECTS ON THE MAGNESIUM OXIDE RESULTS OF VARYING THE CONDITIONS OF CALCIUM OXALATE DIGESTION AND INCREASING THE VOLUME FOR THE OXALATE PRECIPITATION FROM 200 TO 300 ML.

MgO Found, per cent.

	Cement No. 1	Cement No. 2	Cement No. 3
Alternate	1.53	3.01	4.34
ASTM and	1.52	3.06	4.34
Federal Spec.		3.05	4.34
Method			
Average...	1.52	3.04	4.34
15 min on	1.52	3.04	4.34
steam bath	1.52	3.04	4.34
and 300-ml		3.03	4.34
volume			
Average...	1.52	3.04	4.34

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] 1953 Supplement to 1952 Book of ASTM Standards, Part 3, p. 31. Sec. 40(*b*) p. 58.

[2] "Cements, Hydraulic, Methods for Sampling, Inspection, and Testing," April 22, 1952, par. 4.3.5.1.2 Superintendent of Documents, U. S. Government Printing Office, Washington, D. C.

[3] I. M. Kolthoff and E. B. Sandell, "Textbook of Quantitative Inorganic Analysis," The Macmillan Co., New York, N. Y., p. 347 (1948).

[4] L. Bean and E. J. Hackney, "A Study of Some Operations Involved in Cement Analysis." ASTM Bulletin, No. 197, April, 1954. p. 43.

[5] John Redmond, *Journal of Research*, Nat. Bureau Standards, Vol. 10, p. 823 (1933) (*RP 569*).

[6] W. F. Hillebrand, G. E. F. Lundell, H. S. Bright, and J. I. Hoffman, "Applied Inorganic Analysis," 2nd Edition, John Wiley and Sons, New York, N. Y., p. 642 (1953).

LEONARD BEAN is in Charge of Analysis of Cement at the Washington laboratory of the Concreting Materials Section, National Bureau of Standards, where he has been employed since 1941. He is co-author of a number of papers on cement analysis.

NANCY JANE TUCKER, a graduate of The George Washington University, is a member of Joint Committee Fellowship at the National Bureau of Standards on chemical analysis by X-ray diffraction methods for ASTM.

Autogenesis

By Robert S. Rowe

Experiments indicate that for a given concrete mix autogenesis is not only a function of the time of initial curing, time of healing, and type of cure, but also the axial pressure that adjacent sections of the cracked beam are subjected to during the period of self-healing.

THE autogenesis of concrete—heretofore referred to as "autogenous healing"—has frequently been observed and occasionally used beneficially in connection with structural members damaged by cracks. The small scale flexural reconnaissance tests of this paper supply indications of ways in which these and subsequent studies may contribute to a further understanding and usefulness of this interesting characteristic of hardened portland-cement mixtures. The appended references furnish supplementary background information.

For convenience, small sand-cement beams, 1 in. wide, 1 in. deep, and 4 in. long, were tested. Results of tests are given in Table I. The mix used for the beams was one part sand, one part cement, and four-tenths part water by weight.

To induce a crack within the middle third of each beam, third-point loading was applied by means of the homemade lever-type testing machine.

Lever-type constant loading devices were used to apply axial pressure to the ends of each beam during the time the beams were reunited and submerged for the self-healing process.

Initially it was planned to reunite the cracked beams with a constant axial pressure of 1 psi. Soon after tests were begun, it was discovered that the pressure during autogenesis was of utmost importance. This fact, which had not been previously demonstrated, now seems obvious since the rate of chemical processes depends on the proximity of adjacent molecules. Since other research pertaining to autogenesis may be undertaken in the future, it seems desirable that the importance of this observation should not be overlooked.

Up to the limit of compressibility of the concrete, the regain in strength of autogenesis increases with increasing pressure. It is true that the type of cement, aggregate, and water-cement ratio has an influence on autogenesis, but in order to present trends, only one mortar mix was considered. Results are expressed as the actual regain in strength in pounds per square inch (autogenesis) as computed by the flexure formula:

$$f_c = \frac{Mc}{I}$$

TABLE I.—TEST RESULTS.
Values Are Averages.

Number of Beams Tested	Initial Curing Time (Saturated), days	Total Applied Load at Failure, lb	Axial Pressure While Recuring, lb	Time of Recuring (Saturated), days	Total Applied Reload, lb	Autogenesis, psi	Remarks
3....	1.0	137	1	1	0	0	
3....	1.1	131	1	7	0.5	4	
3....	1.2	143	1	28	13.4	53.6	
3....	1.2	141	1	168	5.6	22.4	
2....	1.2	142	10	1.5	1.7	6.8	
2....	1.2	136	10	7	14.0	56.0	
2....	1.2	142	10	28	18.3	73.2	
2....	1.25	156	10	168	33.4	133.6	
2....	1.3	157	100	1.5	4.3	17.2	
2....	1.35	172	100	7	22.0	88.0	
3....	1.4	179	100	28	37.5	150.0	
3....	1.4	171	100	168	45.3	181.2	
2....	1.0	96	500	1	45.0	180.0	
2....	1.1	101	500	7	208.0	832.0	
2....	1.0	101	500	28	226.0	904.0	
2....	1.0	100	500	130	267.0	1068.0	
2....	7	329	100	28	3.5	14.0	
2....	28	366	100	38	3.0	12.0	
2....	35	411	100	168	2.0	8.0	
3....	35	390	500	168	10.5	42.0	
2....	35	381	500	38	3.0	12.0	
12....	1.45	190	Different	Different	0	0	Beams reloaded dry. No autogenesis.
2....	1.4	198	1	28	2.0	8.0	Beam sections separated 1.5 days (saturated) before reuniting under axial pressure.
3....	1.4	182	1	168	6.1	24.4	Beam sections separated 1.5 days (saturated) before reuniting under axial pressure.
3....	1.4	176	2	28	67.6	270.4	Beam sections separated 1.5 days (saturated) but a thin film of cement sprinkled on the sections before reuniting under axial pressure.
3....	1.4	193	1	168	97.3	389.2	Beam sections separated 1.5 days (saturated) but a thin film of cement sprinkled on the sections before reuniting under axial pressure.
2....	1.0	130	100	28	2.0	8.0	Beam sections separated 7 days (saturated) before reuniting under axial pressure.

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ROBERT S. ROWE, Associate Professor of Civil Engineering, Princeton University, Princeton, N. J., is in charge of advanced courses in structures and reinforced concrete, and is currently doing research on concrete and reinforced concrete structures.

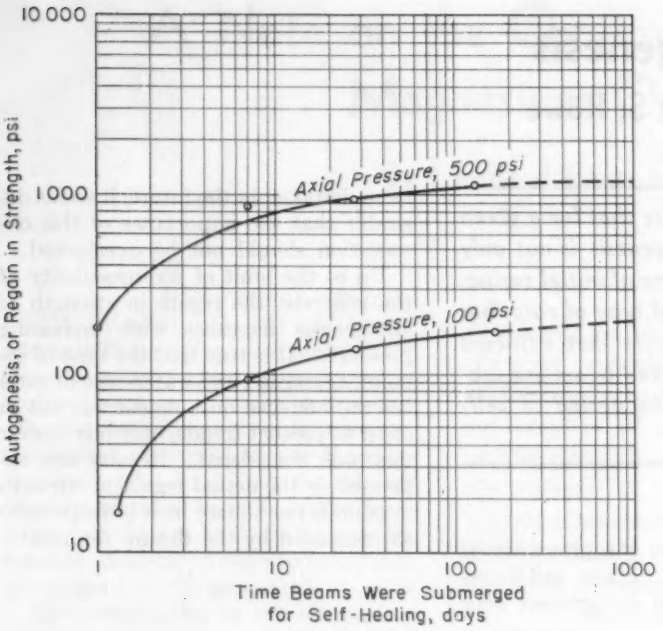

Fig. 1.—Chart Showing Autogenesis, or the Regain in Strength, as a Function of the Time the Beams Were Submerged for Self-Healing, with Axial Pressures of 100 and 500 psi as the Parameter.

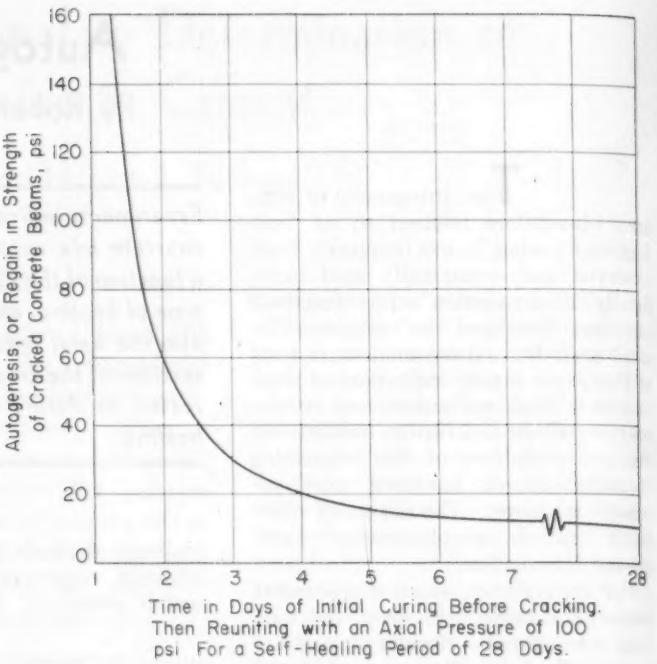

Fig. 2.—Graph Showing the Rapid Decrease in Autogenesis as a Function of the Time of Initial Curing Before Beams Were Loaded to Failure, and Then Reunited with an Axial Pressure of 100 psi for a Self-Healing Period of 28 days.

This method seems to be the best means of comparison as results based on the original strength are questionable and subject to many limitations.

Test results are plotted in Fig. 1. Each plotted point is the average strength of three beams. Values shown are for beams cured one day and then loaded to failure. The sections are then reunited and placed under water with different axial pressures. The duration of time submerged for self-healing is indicated on the chart. In order to show limits conveniently on one diagram, log-log paper is used.

Figure 1 shows the amount of autogenesis in pounds per square inch as a function of the time in days the beams were reunited and submerged for the healing process. Axial pressure is shown on the chart as a parameter.

Petrographic inspection of a section through a crack shows white crystals growing from one face of the crack to the other, filling the void and accounting for the regain in strength. Thus autogenesis is a function of the tensile and compressive strength of the crystals within the crack. There appears to be no autogenesis or crystal growth without the presence of moisture. With increasing axial pressure the crystals formed are smaller and more numerous.

Since autogenesis is increased by axial pressure, it is to be expected that this phenomenon may be an important factor in favor of concrete members subjected to compression, including dams, arches, and members of prestressed concrete. Cracks resulting from accidental overload in prestressed concrete beams may tend to heal when the accidental overload is removed and the beam is again subjected to its precompression. It is quite possible that initial cracking due to erection, shrinkage, temperature, and interruption of pour would tend to heal together.

For a given pressure and the same period of time for self-healing, autogenesis decreases rapidly with increase in time of initial curing before cracking occurs, as shown in Fig. 2. Thus, for average pressures, unless cracking occurs within a week after initial pour, the chance for much autogenesis is slight.

It is interesting to note that autogenesis will probably continue as long as the hydration of the cement continues, regardless of the number of cycles of cracking and recuring. This has been demonstrated experimentally by the results of tests indicated in Fig. 3, which shows the regain in strength, or autogenesis, as a function of the time in days with cyclic recracking and recuring as a parameter. The cycles of recuring are for the same beam subjected to an axial pressure of 100 psi. During the first cycle of recuring for a period of one day, the regain in strength amounted to 20 psi. The beam was then reunited and submerged for a second cycle of curing for seven days. The regain in strength for the second period amounted to 24 psi. After the beam was loaded to failure, reunited, and submerged for the third time for a period of 28 days, the regain in strength amounted to 10 psi. This would indicate that there is a relation between the amount of remaining hydration at any given time to the amount of expected autogenous healing. The relation depends on many factors. Perhaps one of the most important factors which reduces the amount of autogenesis is the localized stress concentration in the vicinity of the cracked section. Another factor which reduces the computed amount of regain in strength due to autogenesis is the smaller moment of inertia of the healed section. The area of healing increases with time; thus, the effective moment of inertia also increases with time. After 28 days, self-healing had covered an average of 60 per cent of the cross-sectional area of the crack, while after 168 days self-healing had covered an area of about 95 per cent. In many cases the healing was so complete that the crack was almost invisible.

Under certain conditions of curing, cracking, and recuring, data pertaining to the autogenesis of self-healing of cracked concrete beams subjected to transverse loads may be obtained experimentally. Evidence recorded herein shows that pressure during the healing period is of primary importance. Inasmuch as autogenesis is a highly complicated phenomenon, only trends for one mix were recorded. It is not an oversight then that the influence of

variations in the type of cement, water-cement ratio, type of aggregate, mix, admixtures, and perhaps many others were not considered.

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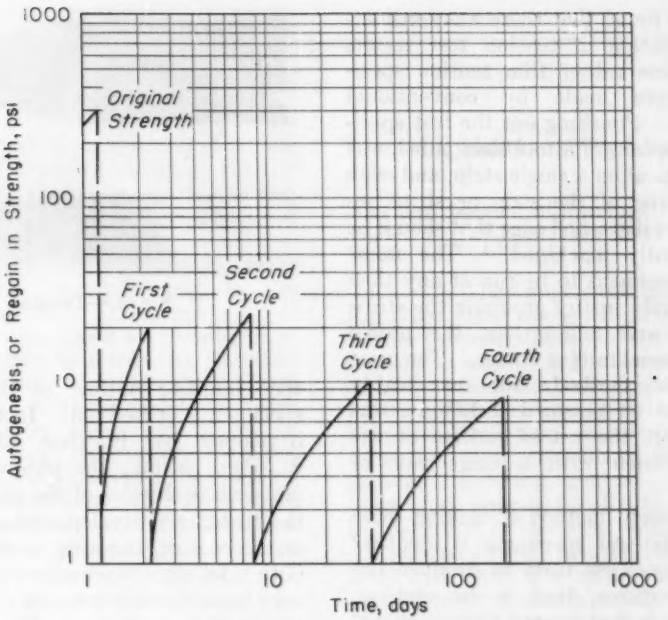

Fig. 3.—Chart Showing Autogenesis, or Regain in Strength, as a Function of the Time in Days with Cycles of Cracking and Recuring the Parameter.

(5) L. C. Urquhart, *Civil Engineering Handbook*, Section 7, "Cement and Concrete by H. J. Gilkey, 3rd Edition, p. 599 (1950).

(6) H. F. Gonnerman, "Autogenous Healing," *Proceedings*, Am. Concrete Inst., Vol. 46, p. 388 (1950). Test report and list of 11 references.

Tension Specimens Made by Photoengraving Technique

By Ralph L. Dowdell and William B. F. Mackay

A method of preparing very thin and flat tension test specimens by etching out the specimen outline by a photoengraving technique gives consistent results as compared to conventional mechanical methods of producing specimens.

FORMERLY metal aperture masks used in the large picture tube of the new tricolor television receivers were made from alloy No. 5 of ASTM Specification B 122.[1] This alloy is composed mainly of 70 per cent copper and 30 per cent nickel, and is generally referred to as a cupronickel. At the present time, most of the masks are made from a copper-nickel alloy containing only 5 per cent nickel. The thousands of small 0.008-in. diameter apertures in the finished mask are produced by etching out the metal by a photoengraving technique.

With the cold-worked 30 per cent nickel alloy in a tensile range of 90 to 120,000 psi, the tensile strength was very critical insofar as the proper functioning of the mask was concerned. This was due to the necessity of prestressing the mask in a mild steel frame to about 30,000 psi before degassing the tube. If this was not done, the masks would not remain flat. Most of the original masks were 0.0035 in. thick, but the present masks of the 5 per cent nickel alloy are usually 0.008 in. thick and are of annealed material that requires no prestressing.

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[1] Tentative Specification for Copper-Nickel-Zinc Alloy (Nickel Silver) and Copper-Nickel Alloy Plate, Sheet, Strip, and Rolled Bar (B 122 – 52 T), 1952 Book of ASTM Standards, Part 2, p. 331.

R. L. DOWDELL, Professor and Head, Department of Metallurgical Engineering, University of Minnesota, has written many technical papers and has had much experience in miscellaneous testing of metals and alloys over a period of 35 years.

W. B. F. MACKAY, Assistant Professor of Metallurgical Engineering, University of Minnesota, has been working in tension testing of cupronickel TV aperture masks and has had considerable experience in the tension testing of thin gage aluminum alloys.

It was found that there was considerable variation in tension test results when these rather thin tension specimens were made by conventional methods. Punching out the test specimen by means of a tool steel punch was not practical on a single strip, and even sandwiching of the strip or strips resulted in a disturbed edge that should be subsequently machined.[2,3] The number of specimens to be run at any time did not fully justify grouping the strips together and milling out the profile with a special milling cutter. The most convenient method, but one highly dependent on personal technique, was to cut out the traced outline of the test specimen with a large pair of scissors.

The present method of making these flat tension-test specimens is identical with the process used to produce the mask apertures, that is, by etching. The strip is first coated with a photoengraving hot top enamel. Then a phototransfer of the test specimen outline is made. The strip is washed to dissolve out the unexposed portion, and the remaining enamel is burned in at a low temperature to make it more resistant to ferric chloride etching so that the complete outline of the tension specimen is etched out. In the process developed by Buckbee Mears Co., St. Paul, Minn., the phototransfer is made on both sides of the strip. After the customary development and drying of the enamel, the strip is etched from both sides simultaneously with an ordinary ferric chloride solution used in photoengraving technique. The edges of these etched out specimens are slightly double beveled.

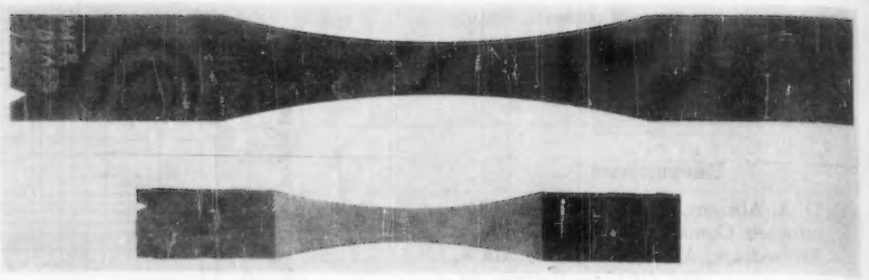

Fig. 1.—Tension Specimens made by Etching Out Technique.

Tension specimens made by this "etching out" technique are shown in Fig. 1. These specimens give much more consistent results on various lots of cupronickel than those made by mechanical methods previously mentioned. In the $\frac{1}{2}$-in. widths commonly used, the variation in width is about ± 0.0001 in. With metals as thin as 0.0035 in. having full hardness by cold working, it appears that tension specimens made by mechanical methods are more susceptible to edge fracturing, due to the shearing operation used on the strip. So far tension specimens having a thickness up to 0.008 in. have been made by this technique. The upper limit of thickness might be about 0.030 in.

This process is far from being universally applicable, but in the application mentioned and possibly in certain other somewhat similar thin gage applications, it is recommended as a convenient method capable of yielding consistent results. The etching process avoids the formation of disturbed metal along the specimen edge, thus producing an edge condition practically free from superimposed stresses.

Acknowledgment:

The authors are indebted to Norman B. Mears, Manager, Buckbee Mears Co., St. Paul, Minn., for permission to report on this special etching technique.

[2] R. L. Templin, "Preparation of Test Specimens," *Metals Handbook*, Am. Soc. Metals, pp. 86–90 (1948).

[3] R. L. Templin, "Effect of Size and Shape of Test Specimens on the Tensile Properties of Sheet Metals," *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part 2, p. 378 (1926).

Plastics for Construction is Conference Topic

A CONFERENCE on "Plastics in Building," stressing the importance of plastics in home, industrial, and institutional construction will be conducted by the Building Research Institute at the National Academy of Sciences in Washington, D. C., October 27 and 28.

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Among the uses to be investigated are plastics for piping, glazing, flooring, ceilings, walls and partitions, roofing, duct work, insulation, and structural parts of buildings. Speakers will be leaders in the plastics and building industries and discussion periods are planned to allow a comprehensive exploration of the practical application, as well as the theoretical possibilities and limitations of plastics materials and products.

This will be the seventh major conference to be conducted by the Building Research Institute, a part of the Division of Engineering and Industrial Research, National Academy of Sciences-National Research Council. The institute is an organization whose members—from business and professional societies, industry and research organizations—are dedicated to improving cross-industry coordination of technical know-how, in order to achieve a better common end product—buildings.

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Free copies may be had on request to J. P. Flynn, Pit and Quarry Publications, 431 S. Dearborn St., Chicago.

The Bookshelf

Lubrication of Industrial and Marine Machinery

W. G. Forbes, C. L. Pope, and W. T. Everitt. 2nd Ed., John Wiley & Sons, Inc., New York 16, N. Y., 351 pp., $6.50

ADDRESSED to the man responsible for the keeping and care of mechanical equipment, this second edition develops and evaluates the fundamental facts basic to an engineer's understanding of present-day lubricating systems.

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The topics in this book are arranged in sequence, and basic principles are evolved in a manner calculated to avoid needless repetition. Relative to the specific lubricating process involved, the authors include expository descriptions of some of the more common types of basic mechanisms, such as compressors, bearings, gears, and pumps.

Materials and Processes

J. F. Young. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1088 pp., $8.50

EXPANDED by 50 per cent over the previous edition, this Second Edition written by Mr. Young, the consultant on the staff of the Vice-President of Engineering, General Electric Co., includes information on current engineering materials and manufacturing processes presented from the engineer's viewpoint. This information may be readily used for the design, production, and control of products. Each chapter is complete in itself so that the book can be used for educational purposes.

Statistical Analysis in Chemistry and the Chemical Industry

C. A. Bennett and N. L. Franklin. John Wiley & Sons, Inc., New York 16, N. Y., 724 pp., $8

THIS volume is a comprehensive treatment of those phases of applied mathematical statistics most useful to chemists and chemical engineers.

The principles of descriptive statistics, probability and samples, mathematical machinery, and statistical inference make up the first portion of the book. In the second part, specialized methods are developed relationships between variables, analysis of variance, the design of experiments, analysis of counted data, control charts, and some tests for randomness are included.

The authors have chosen those techniques most frequently used in the chemical industry. Their selection of methods is also based on the degree of correspondence between the practical situations from which data are obtained and the mathematical models on which inferences from these data must be based. In cases where more than one method is used to achieve the same result, the authors present the theoretical, computational, and practical considerations on which an appropriate selection should be based.

Instrumentation

Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C., $2

FURTHER encouragement to American industry to take advantage of the products of Government-sponsored technical research is this publication listing 775 Government-owned inventions in the field of instrumentation, with a brief description of each invention.

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This volume is the first of a series of seven on Government-owned inventions scheduled for publication this year under the joint sponsorship of the U. S. Department of Commerce and the Small Business Administration.

Proceedings of California Highway Conference

University of California Press, Berkeley 4, Calif., 159 pp., paper bound, $2

THE Proceedings of the 1954 California Street and Highway Conference contain 43 papers and panel discussions under six general headings: highway law; economics; planning and standardizing; urban transportation; traffic and safety; and engineering, construction, maintenance. The California Conference is presented annually by the Institute of Transportation and Traffic Engineering, of the University. It is a conference of road men from all levels of government and the industry.

Thermal Evaluation of Insulating Materials

American Institute of Electrical Engineers, 33 W. 39 St., New York City, 72 pp., $1.50

THE papers collected in this pamphlet were presented at the 1954 Winter General Meeting of the AIEE at sessions sponsored by the Subcommittee on Dielectrics of the Basic Sciences Committee. The sessions grew out of the subcommittee's work in developing information for a revision of the AIEE standard covering general principles upon which temperature limits are based in the rating of electrical equipment.

These papers will be useful in connection with ASTM's own publication, just off press, the Symposium on Temperature Stability of Electrical Insulating Materials, see p. 00.

Collected Papers of Stephen P. Timoshenko

McGraw-Hill Book Co., 642 pp., $15

THIS volume contains most of the papers published at various times in the French, German, and English languages by Stanford University's eminent Professor of Engineering Mechanics. Those of his early papers written in Russian and subsequently translated or abstracted into one of these languages are also included and, for the sake of completeness, the editors have provided a list of his papers written in Russian.

Statistical Theory of Extreme Values and Some Practical Applications

Emil J. Gumbel Lectures. National Bureau of Standards, 51 pp., U. S. Government Printing Office, Washington 25, D. C., 40 cents

PUBLISHED as one of the NBS Applied Mathematics Series, this pamphlet aims to make the statistical theory and techniques of extreme values readily available to scientists and engineers.

The first lecture outlines some of the practical problems to which the theory of extreme values pertains; the second lecture introduces certain new statistical tools necessary for the theory which is developed in the third lecture, first in exact and then in asymptotic form; the fourth lecture shows a series of practical applications and gives all numerical details for enabling interested readers to apply the method to their own problems.

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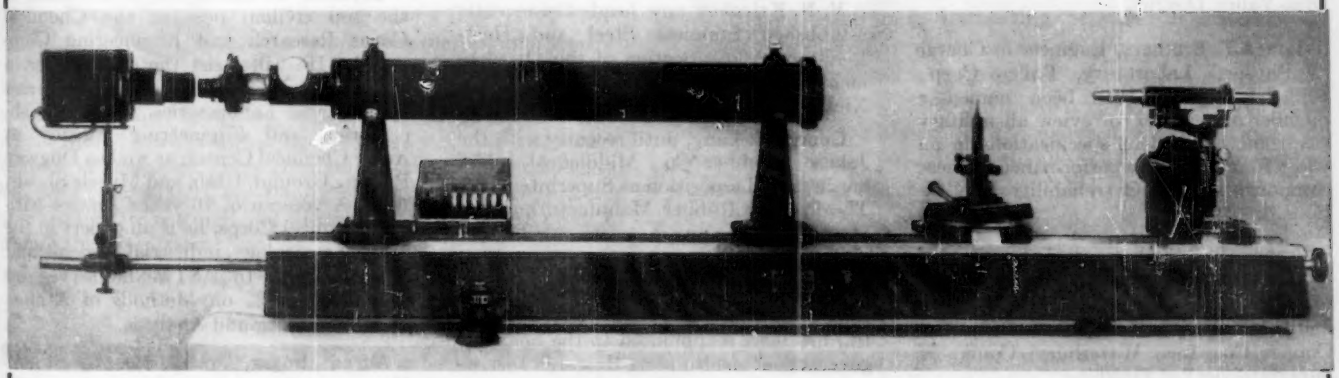

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PERSONALS...

News items concerning the activities of our members will be welcomed for inclusion in this column.

NOTE—*These "Personals" are arranged in order of alphabetical sequence of the names. Frequently two or more members may be referred to in the same note, in which case the first one named is used as a key letter. It is believed that this arrangement will facilitate reference to the news about members.*

Richard H. Bolt has been appointed Professor of Acoustics in the Department of Electrical Engineering at the Massachusetts Institute of Technology. Dr. Bolt has been Director of the interdepartmental Acoustics Laboratory at MIT since 1946 and is one of the unquestioned leaders in the field of acoustics not only in the United States but also internationally. In ASTM he represents MIT on Committee C-20 on Acoustical Materials.

While some of the close friends of **John Bolton** (for many years Director of Metallurgical Research and Testing, The Lunkenheimer Co., Cincinnati, Ohio) know that he retired recently because of ill health, doubtless many others in the Society would be interested to learn that he has dropped his industrial and Society technical work. For many years Mr. Bolton has been handicapped by diabetes and complications—but nonetheless he carried on numerous activities for ASTM and other societies. A recent note indicates that his health is considerably improved and "readjustment is going along fine." A member of the Board of Directors from 1951 to 1954, he was especially active in Committees A-1 on Steel, A-3 on Cast Iron, A-5 on Corrosion of Iron and Steel, and B-5 on Copper and Copper Alloys. He is a former Chairman of Committee A-3, also was one of the organizing members of the Ohio Valley District.

James T. Brothers, Engineer in Charge of Physical Laboratory, Philco Corp., Philadelphia, Pa., has been named a member of a group to review all military electronic component specifications in an effort to improve the performance of these components for high reliability applications.

Francis T. Eddy has accepted a position as Assistant Manager, Technicraft Laboratories, Inc., Thomaston, Conn. He had been associated with Chase Brass and Copper Co., Inc., Waterbury, Conn., as Superintendent of Finishing.

Robert J. Ely has been named Assistant Chief Metallurgist, American Brake Shoe Co., New York City. Formerly Process Metallurgist, Mr. Ely joined the company in 1945.

Sol M. Gleser, until recently Supervising Civil Engineer, Upper Mississippi Valley Div., U. S. Corps of Engineers, Department of the Army, St. Louis, Mo., is now Specifications Engineer, A. M. Kenney, Inc., Cincinnati, Ohio.

Emil A. Gramstorff, Chairman of the Department of Civil Engineering at Northeastern University, has been appointed Dean of the Graduate Division of the College of Engineering, replacing Herbert K. Brown, who, after an extended illness, has requested a full-time teaching assignment in the Department of Mechanical Engineering. Dr. Gramstorff has been active in ASTM for a number of years, serving on Committee C-1 on Cement, also on the New England District Council, of which he is a Past-Officer.

Gordon B. Harvey, formerly associated with the Draper Corp., Hopedale, Mass., is now General Manager, Bonded Fabrics Div., Star Woolen Co., Cohoes, N. Y.

Howard Jackson was promoted to Vice-President in Charge of Production at Pittsburgh and Chicago plants of Hubbard & Co., Pittsburgh. He formerly headed production at the Chicago plant.

J. F. B. Jackson has relinquished his position as Director of the British Steel Castings Research Assn., Sheffield, England, and has joined the Board of A.P.V.-Paramount Ltd. of Crawley, Sussex, as Deputy Managing Director.

Alden M. Klein, formerly Assistant District Manager, Robert W. Hunt Co., New York City, is now Testing Engineer, Brown-Raymond-Walsh, Madrid, Spain.

V. N. Krivobok now heads the recently established Stainless Steel and Heat-Resistant Alloys Section of the Development and Research Div. of International Nickel Co., Inc., New York City.

George E. Lang, until recently with the Johnson Rubber Co., Middlefield, Ohio, has accepted a position as Superintendent, The Premier Rubber Manufacturing Co., Dayton, Ohio.

Haldon A. Leedy, Vice-President and Director of Armour Research Foundation, Illinois Institute of Technology, Chicago, Ill., has been reappointed to the board of governors of the Building Research Inst.

Jess C. Little is now Technical Manager, Electrical Products Div., The Fanner Manufacturing Co., Cleveland, Ohio. He was formerly with Preformed Line Products Co.

John M. Neff, who has been active in ceramic research and development more than 25 years, has been promoted to Manager of the Ceramics and Minerals Research Dept., Armour Research Foundation of Illinois Institute of Technology, Chicago.

Lloyd Osipow, Director, Surface Chemistry Dept., Foster D. Snell, Inc., New York City, is conducting a course in Surface Chemistry at the Polytechnic Institute of Brooklyn.

Theodore P. Pajak has accepted a position as Regional Manager, Hexcel Products Co., Baltimore, Md.

S. E. Printz has retired as Engineer of Tests, Lehigh Valley Railroad Co., Sayre, Pa. Mr. Printz has represented the company membership in ASTM for many years, serving on Committees A-1 on Steel and A-2 on Wrought Iron.

Clarence H. Sample, Chairman, Committee B-8 on Electro-deposited Metallic Coatings, now heads the recently established Electroplating Section, Development and Research Div. of International Nickel Co., Inc., New York City.

Richard G. Scarsibrick, formerly Draftsman, James & Waters and Associates, Palo Alto, Calif., is now Project Engineer, British Columbia Forest Service, Hixon, B. C., Canada.

Chester A. Sellen, Chief Metallurgist and Assistant to the General Manager at Eaton Mfg. Co.'s Reliance Div., Massillon, Ohio, was made Assistant General Manager and Chief Metallurgist.

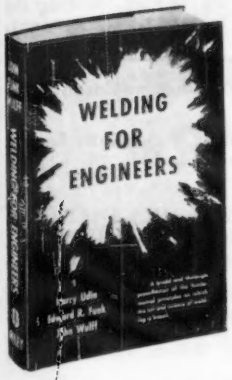
Seymour D. Silver has been named to the top civilian post of the Chemical Corps Research and Engineering Command. He will assist the commander in direction and control of the Chemical and Radiological Laboratories, Medical Laboratories, and Engineering Agency at Army Chemical Center, as well as Dugway Proving Ground, Utah, and Muscle Shoals, Ala. A veteran of 16 years' service with the Chemical Corps, he is an expert in the fields of toxicology, industrial hygiene, and air pollution. In ASTM he serves on Committee D-22 on Methods of Atmospheric Sampling and Analysis.

Alfred Sugar, until recently Plant Manager, Aluminum Div., American Metal Co., Ltd., New York City, is now Vice-President and Technical Director, Alloys & Chemicals Mfg. Co., Cleveland, Ohio.

William J. Troeller, Jr., Assistant Section Head, Research Div., Standard Oil Development Co., Linden, N. J., recently completed 30 years' service with the company. He was presented his award before a group of his fellow employees by Charles L. Fleming, Jr., a director of the Division.

New WILEY Books for Engineers . . .

WELDING for ENGINEERS



By HARRY UDIN, M.I.T.; EDWARD R. FUNK, Goodyear Aircraft Co.; and JOHN WULFF, M.I.T.

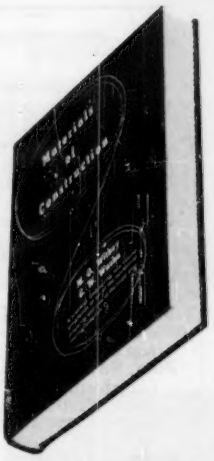
Treating *welding engineering* as a field in itself, this book presents a discussion of the fundamental principles and theory underlying the art of welding. The firm background it offers gives the engineer the know-how to solving a wide variety of engineering problems.

The principles involved come from the fields of physics, chemistry, mathematics, metallurgy and mechanical engineering. Each unit process is presented immediately after its basic principles have been developed.

The discussion includes the joining of metals by brazing; gas, atomic hydrogen and resistance welding; stress concentration and reliefs; inspection and testing; and design of metallurgical aspects. Wherever possible, an analytical approach is taken.

1954 — 430 pages — Illustrated — $7.50

MATERIALS of CONSTRUCTION



By M. O. WITHEY and G. W. WASHA, both of the University of Wisconsin

Provides, in a single volume, a practical time-saving reference for engineers, contractors, architects and others interested in the mechanical properties and uses of engineering materials. Includes the latest data on the sources, manufacture and fabrication of the principal materials used in construction; plus carefully selected information on their more important mechanical and physical properties. Causes of defects and variations, and how they may be discovered, are discussed in simple terms. Accepted testing techniques and some of the apparatus employed are also discussed.

1954 — 887 pages — 419 illus. — $9.00

STRENGTH and RESISTANCE of METALS

By JOHN M. LESSELLS, Consulting Engineer

Here at last is a book which fully describes the *behavior* of metals under stress. It provides the most up-to-date information available on stress conditions such as:

- **Static tension or compression**
- **Creep at elevated temperatures**
- **Cyclically varying stresses, as in fatigue**
- **Suddenly applied loads, as in impact**
- **High surface stresses, as in wear**

Most of the discussion centers around the behavior of steel, but non-ferrous alloys and cast iron are also considered in cases where their behavior differs from that of steel. While simple engineering rules are given throughout, the more fundamental aspects of the subject are also presented. Actual engineering case studies are featured and illustrative problems are given to clarify the discussions.

1954 — 450 pages — 233 illustrations — $10.00

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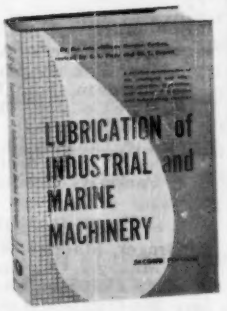

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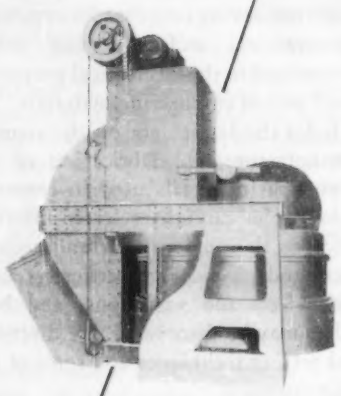

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NEW MEMBERS...

The following 41 members were elected from August 18 to September 21, 1954, making the total membership 7722 . . . . Welcome to ASTM

Note—Names are arranged alphabetically—company members first, then individuals

CHICAGO DISTRICT

Brown, Levi S., Senior Research Petrographer, Portland Cement Assn., 33 W. Grand Ave., Chicago 10, Ill. For mail: 5420 Harrison St., Skokie, Ill.

Clark, Kenneth M., Partner, Kline & Clark, 520 Sexton Bldg., Minneapolis 15, Minn.

Cordova, Francisco J., General Manager, Testing Services, Inc., c/o C. W. Cole and Son, 220 W. La Salle St., South Bend, Ind.

Indiana University Library, Bloomington, Ind.

Meissner, Robert C., Vice-President, John F. Meissner Engineers, Inc., 308 W. Washington St., Chicago 6, Ill.

Pulo, Edward John, Packaging Technologist, Quartermaster Food and Container Inst., 1819 W. Pershing Rd., Chicago, Ill. For mail: 1639 W. Eighteenth Pl., Chicago 8, Ill.

Rodriquez, Alfred, Assistant Vice-President, Material Service Corp., 300 W. Washington Blvd., Chicago 6, Ill.

CLEVELAND DISTRICT

Johnson, Stephen, Jr., Chief Engineer, Bendix - Westinghouse Automotive Air Brake Co., 901 Cleveland Rd., Elyria, Ohio.

DETROIT DISTRICT

Shannon, Francis Joseph, Chief Engineer, Continental Die Casting, 9615 Grinell St., Detroit, Mich. For mail: 18267 Rosemont Rd., Detroit 19, Mich.

Ziegler, Earl E., Plastics Technical Service, Dow Chemical Co., Midland, Mich.

NEW ENGLAND DISTRICT

Clark, George F., Manager, Chemo-Textiles, Inc., Box 169, West Warwick, R. I.

Richardson, John M., President, Brookfield Wire Co., Inc. For mail: Box 35, Brookfield, Mass.

Tuttle, Lansing, Engineer of Technical Service, Warren Brothers Co., 33 Cambridge Parkway, Cambridge, Mass.

NEW YORK DISTRICT

Groger, Maurice W., President and General Manager, Condenser Service and Engineering Co., Inc., Hoboken, N. J. For mail: 366 Highland Ave., Orange, N. J.

Jacoby, Ernest H., Project Engineer, Flexible Tubing Corp., New Whitfield St., Guilford, Conn.

Jones, Robert R., Quality Control Superintendent, Bigelow-Sanford Carpet Co., Inc., 37 Prospect St., Amsterdam, N. Y.

Shatzky, Jacob, Mechanical Engineer, Margon Corp., 717 Ave. A, Bayonne, N. J. [J]*

Singstad, Ole, Partner, Singstad & Baillie, 24 State St., New York 4, N. Y.

Unholtz, Karl, Chief Engineer, The MB Manufacturing Co., Inc., 1060 State St., New Haven 11, Conn.

OHIO VALLEY DISTRICT

Kelley, John R., Partner, Allen & Kelley, 435 Architects and Builders Bldg., Indianapolis 4, Ind.

Sjodahl, Lars, Technical Supervisor, Middletown Carton Plant, Gardner Board and Carton Co., 407 Charles St., Middletown, Ohio.

ST. LOUIS DISTRICT

Bardahl Oil Co., Leon Kresser, Director of Research, 5635 Natural Bridge Blvd., St. Louis, Mo.

Lawrence, L. Gillette, Supervisor, Laboratory, AFC Industries, Inc., St. Charles, Mo.

SOUTHERN CALIFORNIA DISTRICT

Southwestern Engineering Co., R. V. Gunther, Vice-President, 4800 Santa Fe Ave., Los Angeles 58, Calif.

Brandt, Kristian H., Senior Research Engineer, Solar Manufacturing Co., E. 46th St. and Seville Ave., Los Angeles 58, Calif. For mail: 1308 N. Wilson Ave., Pasadena, Calif.

Faber, Barry T., Engineer, Faber Laboratories, 1025 Georgia St., Los Angeles 15, Calif.

Guinn, Charles L., Vice-President, Engineering, Anja Engineering Corp., 5426 Alhambra Ave. For mail: 163 S. Edinburgh, Los Angeles 48, Calif.

SOUTHWEST DISTRICT

Anderson, Robert Clark, Metallurgical Engineer, WKM Co., 221 Roberts, Houston, Tex. For mail: 8246 Bonner Dr., Houston 17, Tex.

Cooley, Herbert M., Assistant Metallurgical Engineer, Bethlehem Steel Co., Box 2171, Tulsa 2, Okla.

WASHINGTON (D. C.) DISTRICT

De Milia, Joseph, Electrical Engineer, Engineering Dept., U. S. Naval Gun Factory, Eleventh and M Sts., S. E., Washington 16, D. C. For mail: 4812 41st St., N. W., Washington 16, D. C.

Kahn, Asher D., Partner, Wolfkill Vault Service, Hagerstown, Md. For mail: Box 226, Hagerstown, Md.

Valore, Rudolph C., Jr., Material Engineer, National Bureau of Standards, Washington 25, D. C.

WESTERN NEW YORK-ONTARIO DISTRICT

Burke, E. J., Hanna Furnace Corp., Buffalo 2, N. Y. For mail: 1000 Walbridge Bldg., Buffalo 2, N. Y.

UNITED STATES AND POSSESSIONS

Bullwinkle, Benjamin B., Vice-President, Tuerck-Mackenzie Co., 687 N. Thompson St., Portland 12, Ore.

Cook, John C., Professional Engineer, Washington Testing Laboratories, North 118 Browne, Spokane 1, Wash.

Mills, Blake D., Jr., Professor of Mechanical Engineering, Mechanical Engineering Dept., University of Washington, Seattle 5, Wash.

Pogue, R. H., Jr., Chief Engineer, General Steel Tank Co., Inc., Box 552, Birmingham 1, Ala.

OTHER THAN U. S. POSSESSIONS

Guzstahlwerk Bochumer Verein A. G., S. Ammareller, Director Metallurgical Dept., Bochum (British Zone), Germany.

Banerjea, Harendra Nath, Assistant Manager, The Associated Cement Co., Ltd., Porbandar, Saurashbra, India.

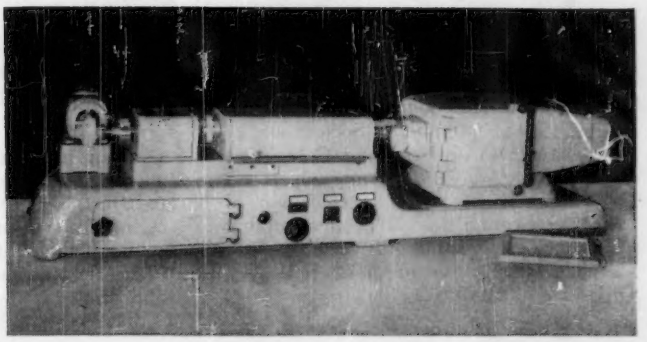
Battelle Memorial Inst., International Div., 7 Route de Drize, Geneva, Switzerland.

Clube de Engenharia, Avenida Rio Branco, 124, Rio de Janeiro, Brazil.

Fujita, Kin-Ichiro, Director, Building Research Inst., 4-chome, Hyaknin-cho Shinjuk-ku, Tokyo, Japan.

* [J] denotes Junior member.

New Amsler
TESTING MACHINES NOW AVAILABLE



The Amsler Horizontal Tensile Testing Machine has been designed for testing materials of small section or low tensile strength such as fine wires, foils, fibers, fabrics, paper, yarn, leather, rubber, etc. The long horizontal design permits easy access to all parts, unobstructed view of the specimen, convenient gripping mechanisms and sufficient travel for specimens of great elongation such as rubber.

All of the desirable features in a small testing machine are included, such as the highly accurate pendulum load weighing system, five load ranges for greatest sensitivity at all loads, and speed control variable through eight steps from 0.1 to 20 inches per minute.

The tensile load applied is balanced by the deviation of the pendulum from the vertical position. The movement of the pendulum is indicated on a straight line scale located in front of the operator for easy reading. The pointer remains at the maximum load after fracture of the sample. The recording drum is located directly below the load scale. The recorder will plot the elongations as 1/5 size, actual size or double size.

A split nut arrangement on the pulling grip allows quick positioning of this grip to accommodate different length specimens. A wide variety of jaws and clamps are available for holding the different samples.

The Chevenard Micro Tensile Testing Machine has been designed for testing materials of very low strength or of micro dimensions. Samples with a breaking strength as low as one gram (0.035 oz.) may be tested. The machine, however, is extremely versatile having a maximum capacity of 100,000 times the minimum capacity of 100 kg. (220 lbs.). This broad range is obtained by the use of interchangeable dynamometer springs. The pulling speed can be varied between 6 and 300 mm. (0.24 and 12 in.) per minute. This is accomplished by the use of a variable speed motor and a sliding gear change box.

Two interchangeable optical tripods utilizing a light beam and photographic recording provide the utmost sensitivity in the measurement of elongation and the recording of stress-strain curves. Specimens can be tested dry or in a liquid bath and may be from 2 to 150 mm. (0.08 to 6.0 in.) between grips. The grips will accommodate specimens up to 6 mm. (0.24 in.) wide.

A micrometer and accessories are included for carrying out load-elongation cycles between two given values of elongation. The tester is also equipped with an automatic device for carrying out cycles between two given values of the load.

All of these features make the tester ideal for research or control tests on wire or thin metal strip, natural or artificial fibers and textiles, threads, tissues, paper, films of paint or varnish or similar materials.

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DEATHS...

Carl C. Ahles, Engineer of Location and Design, New York State Department of Public Works, Albany, N. Y. (April, 1954). Member of ASTM and of Committee C-1 on Cement from 1934 to 1953.

Ambrose R. Chantler, retired du Pont official, died in Delaware Hospital, Wilmington, Del., July 28, 1954, after a long illness. He had been with du Pont in various capacities from 1919 to 1952. Mr. Chantler had served for a number of years on the ASA Sectional Committee L 14 on Textile Test Methods, representing the Synthetic Organic Chemical Mfrs. Assn.

George L. Cherry, Western Electric Co., Chicago, Ill. Representative of his company from 1943 to 1952 on Committee B-6 on Die-Cast Metals and Alloys.

T. W. Guy, Consulting Engineer, Coal Preparation, Charleston, W. Va. (September 11, 1954). Member of Society and of Committee D-5 on Coal and Coke since 1933, serving on several subgroups, and for a number of years as chairman of former Subcommittee XII on Sampling Coal at Coal Cleaning Plants. Mr. Guy also had been active in the Ohio Valley District Council since 1949.

John Hunter Nead, former Metallurgical Consultant to the President, Inland Steel Co., Chicago, Ill. (September 13, 1954). Affiliated with ASTM since 1911, Mr. Nead had been active through the years in Committee A-1 on Steel, and former Committee A-4 on Heat Treatment of Iron and Steel, and several of the respective subgroups. He also served for a number of years on Committee E-4 on Metallography. Well known and recognized in his field, he was a member of numerous technical and professional organizations—a Past Chairman of the Iron and Steel Division, American Institute of Mining and Metallurgical Engineers, and a Past Director of the American Society for Metals. He had many friends in the ASTM membership. Prior to joining the Inland Steel staff in 1931, he had been associated with the American Rolling Mill Co., Minneapolis Steel & Machinery Co., Watertown Arsenal, and the Franklin Motor Car Co.

Edison Junqueira Passos, Public Works Commissioner, City of Rio de Janeiro Administration, Brazil (June 11, 1954). Member since 1931.

Lucien Ingraham Yeomans, President, Lucien I. Yeomans, Inc., Chicago, Ill. (August 16, 1954). Member since 1911. An engineering consultant on shell-making, toolmaking, and other manufacturing since 1913, Mr. Yeomans was recipient of the John Scott Legacy Medal of the Franklin Institute in 1918 for method of machine design. He authored the books "Shell Making Machinery" and "Shell Processing," both written for the U. S. Army Ordnance Department in 1940.

Roderick B. Young, Concrete Consultant, and former Associate Director of Research, The Hydro-Electric Power Commission of Ontario, Toronto, Canada (August 24, 1954). Affiliated with ASTM since 1916, Mr. Young had been active in Committees C-1 on Cement and C-9 on Concrete and Concrete Aggregates since 1919. He was Secretary of the Cement Committee for four years, also served a similar period as Vice-Chairman. He organized the Subcommittee on Ready Mixed Concrete of Committee C-9 in 1930 and headed this group as chairman until 1949. In recognition of his valued contributions to ASTM work, he was granted an ASTM Award of Merit at the 1953 Annual Meeting, the citation emphasizing his "pioneering work in concrete research, his many years of service to the Society, and the inspiration of his example and leadership." Associated with other technical and professional organizations, Mr. Young was a Past-President and Honorary Member of the American Concrete Institute and recipient of a number of honors recognizing his outstanding contributions to a better knowledge of cement and concrete, and control of their quality. With his passing ASTM loses an esteemed and loyal supporter.

NEWS NOTES ON

Laboratory Supplies and Testing Equipment

Please mention ASTM BULLETIN when writing to suppliers

INSTRUMENT NOTES

Curved Crystal X-Ray Quantometer—Production of a new, curved crystal, multichannel X-ray Quantometer has been announced by Applied Research Labs. It has been designed specifically for the rapid, nondestructive chemical analysis of metals, powders, and liquids. Complete information available from manufacturer.

Applied Research Laboratories, Glendale, Calif.

Test Unit Improves Stroboscopic Observation—A new portable, self-contained, electronic test device for vibration and shock analysis has been marketed by the York Division of the Bendix Aviation Corp. According to the announcement the unit eliminates the time-consuming adjustments required of former methods to synchronize the speed of light flashes with the vibration of the object being tested.

York Div., Bendix Aviation Corp., York, Pa.

New Multiplexer Unit—As many as ten synchronized sweeps can be thrown at one time on the screen of a single-gun oscilloscope with the aid of a new electronic device developed by Burroughs Corp. The multiplexer can throw separate sweeps onto the face of an oscilloscope at the rate of 500,000 a second.

Burroughs Corp., Electronic Instruments Div., 250 N. Broad St., Philadelphia, Pa.

Small Spring Tester—Testing small compression and extension springs for loads and deflections can be done with extreme accuracy on a newly redesigned precision instrument recently announced by The Carlson Co. The capacity is $\frac{1}{64}$ oz to 12½ lb with spring lengths from $\frac{1}{8}$ to 12 in. long. The accuracy is guaranteed within $\frac{1}{4}$ of 1 per cent.

The Carlson Co., 277 Broadway, New York 7, N. Y.

Climatic Test Chamber Simplifies and Speeds Temperature Tests—A compact new climatic test chamber has been designed by Conrad, Inc. for rapid, exact temperature tests under varying conditions or cycles of wire and cable. Temperature cycles can be automatically controlled between +300 and −100 F, or held at fixed points within this range, as needed.

Conrad, Inc., 183 Jefferson Ave., Holland, Mich.

New Cathode-Ray Oscillograph—The Du Mont Type 327, a new cathode-ray oscillograph capable of precise measurements of time and amplitude within the frequency range of dc to 5 mc is announced by the Instrument Div., Allen B. Du Mont Labs. Complete information available upon request from Technical Sales Dept.

Allen B. Du Mont Labs., Inc., 760 Bloomfield Ave., Clifton, N. J.

Automatic Leveling Instrument—The Cowley Compactic Automatic Level is being introduced by Engis Equipment Co. Its patented optical principle employs no cross hairs, bubbles, or leveling screws. The unit need only be placed on its tripod or stand to indicate automatically whether the target is level.

Engis Equipment Co., Compactic Div., 431 S. Dearborn St., Chicago 5, Ill.

Heat-Sensing Cell with 10,000-Time Sensitivity Boost—Little slips of glass coated with lead sulfide that can give 10,000 times as much sensitivity to certain infrared rays as previous laboratory instruments have now been put on sale to

(*Continued on page 76*)

LOCKHEED AIRCRAFT REPORTS:

"Our Baldwin FGT SR-4® testing machine is invaluable!"

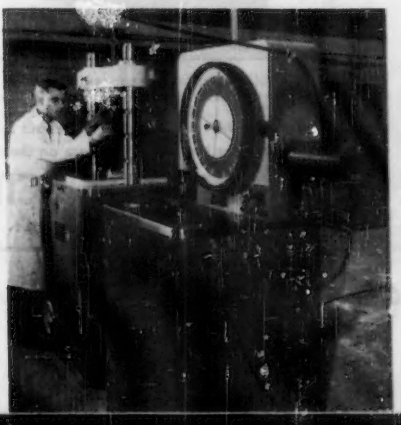
"We don't have 'routine' production line tests . . . each test we get is likely to be entirely different from any we've run before," explains the Engineering Test Group of Lockheed Aircraft's Engineering Test Laboratory, Marietta, Ga. "That's why the new Baldwin-Emery FGT SR-4 Universal Testing Machine fits our needs so well. This single revolutionary machine is not only easy to operate and extremely accurate, but is flexible as well."

These photographs show just two of the diverse tests Lockheed is making on their 50,000 pound FGT machine . . . the closeup shows a round piece of aluminum stock being tested with the Baldwin SR-4 Extensometer added for accurate control . . . the smaller picture shows how Lockheed obtains the ultimate adhesion strength of a metal-to-metal bond within very accurate tolerances.

Your laboratory, too, will profit by using this unique, versatile testing machine . . . for any of these diverse tests; static tension, compression, flexure, torsion, creep, stress rupture, relaxation, or even shock tests on structures. For the full story on this example of Baldwin's "Packaged Precision Measurement," write us for our new Bulletin 4206. Address: Dept. 2403, Baldwin-Lima-Hamilton Corporation, Philadelphia 42, Pa.

See the FGT in action at Baldwin's Booth 1065, 36th National Metal Congress & Exposition, International Amphitheatre, Chicago, November 1-5.

BALDWIN BLH LIMA-HAMILTON



TESTING HEADQUARTERS

BALDWIN-LIMA-HAMILTON

General Offices: Philadelphia 42, Pa. Offices in Principal Cities
In Canada: Peacock Bros., Ltd., Montreal, Quebec

(*Continued from page 74*)

science and industry by the Eastman Kodak Co. Known as Kodak Ektron Detectors, the new photoconductive cells were first unveiled at the 57th Annual Meeting of the American Society for Testing Materials. Though the cell reaches its peak of sensitivity in the invisible heat rays of the near-infrared, it is highly sensitive to all colors of visible light and on into the ultraviolet.

Eastman Kodak Co., Rochester 4, N. Y.

Indicating Temperature Controller—A remote indicating temperature controller accurate within 1 per cent of full scale under most conditions has been developed by Fenwal Inc. It is designed for economical yet accurate temperature control in ovens, packaging and processing equipment of all types. Called the Series 540, the new controller has a temperature operating range of 100 to 700 F with uniform sensitivity throughout the range. Further information from the manufacturer.

Fenwal Inc., Ashland, Mass.

New Accuracy for Particle Sizing—Fisher Scientific Co. announces a Calibrator attachment for the Sub-Sieve Sizer. This instrument measures particles too small for sieves (its range: 0.2 to 50 microns) by determining the resistance to air flow of a weighed sample under standard packing conditions.

Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.

New Batch Type Ovens—A complete standard line of Batch Ovens, available with either gas or electric heat source has been announced by Grieve-Hendry Co., Inc. These ovens have been found especially adaptable for "burn-off," also many other uses including baking all new types of finishes, preheating, drying, curing, dehydrating, and all types of baking operations. Air circulation is automatic, both horizontal and vertical, completely surrounding the work to assure uniform temperature. Full details from the manufacturer.

Grieve-Hendry Co., Inc., 1401-17 W. Carroll Ave., Chicago 7, Ill.

Direct Reading Spectrometer—The Atomcounter, a direct reading spectrometer that incorporates many new electronic, optical, and mechanical design innovations, has been announced by Jarrell-Ash Co. The new instrument may be used photographically for qualitative or photo semiquantitative analysis simultaneously with or alternatively to the direct reading measurements. It is also furnished as a single deck direct reading system for use in the analysis of simple steels and cast iron.

Jarrell-Ash Co., 26 Farwell St., Newtonville, Mass.

Smoothness Tester—The RD Smoothness Tester for determining smoothness of both the felt and wire sides of paper, separately and simultaneously, is available from W. & L. E. Gurley. The test consists of comparing the paper sample against optically flat metal surfaces, by determining the rate at which air flows between the two.

W. & L. E. Gurley, Industrial Div., Troy, N. Y.

Test Sieve Vibrator for Accurate Screen Analysis—By its simultaneous gyratory and vibratory movements, the LANCO Laboratory Test Sieve Vibrator speedily passes particles through screens and segregates the different sizes in the proper sieves. Movement of the table is not rotary but like an inclined disk rolling around its perimeter. As the table gyrates, it simultaneously vibrates a fraction of an inch 300 times a minute.

Arthur S. LaPine & Co., 6001 S. Knox Ave., Chicago 29, Ill.

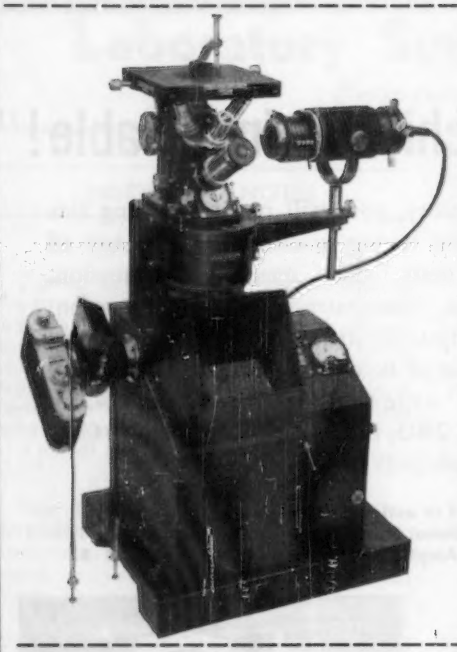
Proportional Counter—Nuclear Measurements Corp. has developed a new proportional counter converter with built-in low voltage power supply and needle valve for gas flow control. The new unit, Model PCC-14, converts any scaler with a high voltage range of 600 to 2000 v to a reliable proportional counter. It is designed to count such samples as precipitates, evaporated salts, compressed pellets, ashed and filtered samples.

Nuclear Measurements Corp., 2460 N. Arlington Ave., Indianapolis 18, Ind.

Survey Meter for Laboratory or Field Use—The Model 2612 is a completely redesigned portable, battery-operated G-M survey meter for measuring alpha, beta, and gamma radiation. The instrument is provided with choice of probes utilizing a

(*Continued on page 78*)

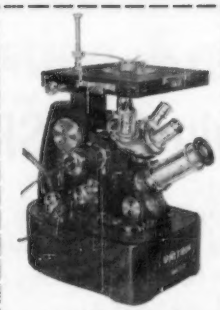
METALLURGICAL MICROSCOPES by UNITRON



UNITRON METALLOGRAPH and UNIVERSAL CAMERA Microscope, New Model U-11

- For visual observation, measurement, and photography of both opaque and transparent specimens.
- Bright field, dark field, and polarized illumination.
- Revolving nosepiece with 5 objective lenses, 4 photographic eyepieces, 3 visual eyepieces. Coated optics. Magnification range: 25-2000X.
- Compact and entirely self-contained with built-in 3¼" x 4¼" camera, high-intensity illuminator, variable transformer.
- The image is automatically in focus in the camera—transition from observation to photography is instantaneous.
- Transmitted light accessories for transparent specimens included.
- Calibrated square mechanical stage with rotatable stage plate.
- Many other important features and accessories including polarizing apparatus, filters, micrometer eyepieces, film holders, etc. Cabinet.
- 35 mm camera attachment and low power (5-40X) accessories available at extra cost.

COMPLETE UNIT only fob Boston **$1145.**

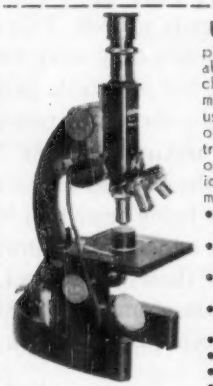


UNITRON Model MEC

is of the inverted type and designed for visual observation of metals, ores, minerals, etc. It includes many of the features of the Model U-11 Metallograph which are connected with visual observation of oblique specimens. 25-1500X.

- transformer built into microscope base.
- vertical illuminator with iris diaphragm and filters.
- coarse and fine focusing.
- large mechanical stage with graduated circular rotatable stage plate.
- calibrated polarizing apparatus.
- revolving nosepiece with objectives 5X, 10X, 40X, 100X oil.
- eyepieces: P5X, Micrometer 10X, K15X.

COMPLETE only fob Boston **$319.**



UNITRON Model MMU

pioneers several new features available for the first time, as well as including features found only in instruments selling for over twice our unusually low price. For metals and other opaque specimens and also transparent specimens, under both ordinary and polarized light. An ideal, all-purpose, laboratory instrument. 25-1500X.

- transformer built into microscope base.
- vertical illuminator with iris diaphragm and filters.
- illuminator mounts on stage for oblique lighting.
- illuminator mounts substage for transparent specimens.
- coarse and fine focusing.
- focusable stage.
- calibrated drawtube.
- polarizing apparatus.
- revolving nosepiece with objectives 5X, 10X, 40X, 100X oil.
- eyepieces: P5X, P10X, K15X.

COMPLETE only fob Boston **$287.**

UNITRON Metallurgical Microscopes are chosen by leading firms such as Union Carbide & Carbon, Goodyear Atomic, General Motors, American Smelting and Refining, CBS-Hytron, Sperry Products, Raytheon, etc. These companies are particularly well equipped to appreciate precision workmanship, value, and quality. Why not find out more about these fine instruments?

Write for illustrated literature on these and other UNITRON Mjcroscopes.

UNITED SCIENTIFIC CO.

204-6 MILK ST. Dep't. MT-10 Boston 9, Mass.

Kodak reports to laboratories on:

where to look for organic chemicals... high speed film for high speed movies... the most sensitive lead sulfide photoconductive cell available

List No. 39

This and every year, myriads of companies spawn numberless catalogs, each a jewel in the crown of some sales manager, each a brick in the edifices of the printing industry and the filing cabinet industry. Here *we* come with yet another and with the presumption to proclaim its advent an event. In support we

cite the reception accorded the 38 predecessors of the vivid turquoise *Eastman Organic Chemicals List No. 39*, which has just been mailed out to those who have told us in past years that they would want it.

We speculate sometimes on why the Eastman Organic catalog is in such high demand by working practitioners of science. Among the more tenable hypotheses, may be listed:

1. It's handy to have around a book weighing less than a pound that gives the *Chem Abstracts* names, laboratory-quantity prices, structural formulas, molecular weights, and melting or boiling ranges (observed, not just quoted) of a representative group of some 3500 organic compounds.

2. It provides a means of distinguishing between the hundreds of thousands of organic compounds known to exist and those actually obtainable by mail or phone order from a single, eminently responsible source (148 items have been added to the latter class in the new edition).

3. It provides routine but useful compilations on matters like pH indicator ranges; transparency regions of spectrophotometric solvents; reagents for a great host of analytical tests; liquids for refractive index determination; listings of sugars, vitamins, amino acids, alkaloids.

Now is the time for anyone who needs to know about the availability of organic compounds for the laboratory and who has not yet received List No. 39 *to demand it of Distillation Products Industries, Eastman Organic Chemicals Department, Rochester 3, N. Y. (Division of Eastman Kodak Company). Though the catalog is free for the asking and the rate of its distribution has been accelerating at a mad pace for the past 35 years, we are always running into deserving people who want it but don't have it. Can't figure that.*

High speed boon

In Paris this month at an international symposium on high speed photography, we are announcing 16mm *Cine-Kodak Tri-X Negative Film*. We are making a scholarly and dispassionate exposition of the factors governing choice of emulsion characteristics for high speed motion pictures and in due course of the argument we bring out that the new film has at least twice the speed of the valiant old "Super-XX," with about the same graininess. The happy implication to the man with a *Kodak High Speed Camera* is that he can close down his lens to get more depth of field, or he needn't pour so much light on his subject.

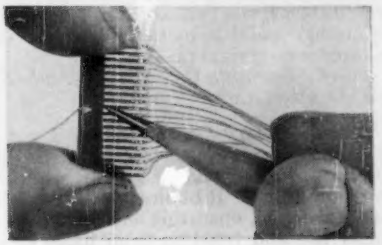
Cine-Kodak Tri-X Negative Film is now obtainable from your Kodak dealer, not only spooled for the rigors of high speed cameras (and so labeled) but also for more orthodox 16mm movie cameras used in newsreel, industrial, and sports photography. ASA Exposure Indices for conventional work are 250 for daylight and 200 for tungsten. Actually, this film outstrips the vision of some exposure meter designers by often making possible a quite adequate picture under illumination so low that the photographer can't get any response out of his meter.

For a technical data sheet on Tri-X *motion picture film, write Eastman Kodak Company, 343 State Street, Rochester 4, N. Y. We do not process this film.*

Ektron detectors

We are going to stop being coy about it and come right out and say that a certain manufacturer of materials for "chemical photography" whose name appears at the bottom of this page is now also manufacturing the most convenient device for the *electrical* detection of radiant energy.

It is called the *Kodak Ektron Detector*. It is the most sensitive lead sulfide photoconductive cell presently available. Its response to a 2500 K tungsten light source is about the same as that of a red-sensitive gas-filled phototube of comparable sensitive area under comparable conditions. But vibration doesn't bother it, for it consists merely of a prepared surface, operating right out in the open. Even more important, the sensitive surface can be of any size or shape. The 20 little black dots on this ¾-inch slip of glass, for example, are individual photoconductive cells.



So far you've read only half the story, possibly the less significant half. Though the *Kodak Ektron Detector* competes with the phototube and photomultiplier on their home grounds in the visible spectrum, it reaches its maximum sensitivity at 2μ in the infrared. At 2.7μ, operating at room temperature, it gives a hundred times the response of a good laboratory bolometer. All in all, the useful response extends from 0.3μ in the ultraviolet to 3.5μ in the infrared. Usable frequency response is from steady illumination to 5,000 radiation pulses per second.

This thing is more than a gleam in our eye. We are in production and can accept orders today. You transact your business with a man named W. F. Swann at Eastman Kodak Company, Rochester 4, N. Y. He can tell you about the various structural types of Kodak Ektron Detectors, *the many sizes and shapes in which we make them, and the story on matched sets and multiple-detector units. Figure from $14 to $24 apiece for the various standard* Kodak Ektron Detectors *you'll need for working out your ideas. We can talk later about quantity prices.*

Prices quoted are subject to change without notice.

This is one of a series of reports on the many products and services with which the Eastman Kodak Company and its divisions are... *serving laboratories everywhere*

Kodak

(*Continued from page 76*)

thin wall Geiger Tube for both beta and gamma radiation of over 0.2 mev, or a thin mica end window counter for alphas, betas, and gammas.

Nuclear Instrument and Chemical Corp., 229 W. Erie St., Chicago 10, Ill.

Strain Instrument—For measuring large motions on specimens undergoing tension testing, a new type of strain measuring instrument has been developed by the Tinius Olsen Testing Machine Co. Used in conjunction with the Olsen Model 51 Electronic Recorder, the R-40 extensometer has magnifications of 1, ½, and ¼ for recording motions of 10, 20, or 40 inches. Further information available upon request.

Tinius Olsen Testing Machine Co., 1200 Easton Rd., Willow Grove, Pa.

Hydraulic Tension Testing Machine—A low cost hydraulic tension testing machine to meet the Army, Navy, Federal, and ASTM specifications for a guaranteed accuracy of ±1 per cent of indicated load is being marketed by the Pacific Scientific Co. The unit is utilized for spot weld certifications, rivet shear, terminal pull-off strengths, metal-to-metal adhesives, and flexure tests on rigid plastics.

Pacific Scientific Co., 2614 W. 9th St., Los Angeles 6, Calif.

Improved Low-Cost Vacuum Oven—Precision Scientific Co. has redesigned its Thelco Vacuum Oven for greater accuracy and durability. Ribbon-type heater elements are used, operating at black heat for longer life and freedom from hazard. A sensitive hydraulic thermostat with external adjustment knob permits exact resetting to temperature.

Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

CATALOGS AND LITERATURE

Laboratory News—A new issue of the *Aminco Laboratory News* has been published by the American Instrument Co., Inc. Equipment listed includes: high vacuum coating evaporator, apparatus for micro and semimicro nitrogen determinations, peristaltic-action pump, freezing-point depression apparatus, instruments for testing rubber and rubber-like materials, and soil.

American Instrument Co., Inc., Silver Spring, Md.

Capacitrols—Model 297 Capacitrol, announced by Wheelco Instruments Div., Barber-Colman Co., has been designed for accurate indicating and instantaneous control required by new plastic machines, methods, and materials. This instrument uses plug-in components for both the temperature measuring system and the control chassis. Write for copy of *Bulletin F 6476.*

Barber-Colman Co., Instruments Div., Rockford, Ill.

Wrist-Action Shakers—Burrell Corp. has introduced a new line of laboratory shakers. *Bulletin No. 307* describes the instruments and lists catalog numbers, prices, and other ordering data, as well as capacities and dimensions.

Burrell Corp., 2223 Fifth Ave., Pittsburgh 19, Pa.

D-C Indicating Amplifier—Now available from the Doelcam Corp. is *Bulletin 1A* describing Type 2HLA-3 d-c indicating amplifier. The bulletin also includes a photographic illustration, detailed description, typical applications, and a discussion of the principle of operation.

Doelcam Corp., 1400 Soldiers Field Rd., Boston, Mass.

Ultraviolet Monochromatic Illuminator—The UV Monochromatic Illuminator is small, compact, and convenient to use with microscopes, colorimeters, photometers, and similar instruments. It is designed to yield monochromatic illumination at any chosen wavelength between 220 and 440 mμ. *Bulletin No. 811* available upon request.

Farrand Optical Co., Inc., Bronx Blvd. & E. 238th St., New York 70, N. Y.

Versatile Laboratory Stirrer—A new three-speed stirrer designed for continuous, light duty operation at 500, 750, or 1000 rpm has been announced by Eberbach Corp. *Bulletin No. 490* illustrates and describes the stirrer and its components and accessories.

Eberbach Corp., Ann Arbor, Mich.

Color Control for Chemists—Eight-page profusely illustrated bulletin recently published by Fisher Scientific Co. explains the theory and use of a new additive colorimeter designed to serve as a permanent "color memory" for control chemists in the paint, food, textile, paper, plastics, linoleum, printing, and ceramic industries. *Bulletin FS-246* available from company.

Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.

Lubricants—A new four-page folder listing service recommendations for industrial lubricants has been announced by Gredag, Inc. Grades of "Gredag" lubricants are specified for various applications.

Gredag, Inc., Niagara Falls, N. Y.

Assessment of Surface Finish—A ten-page booklet issued by William J. Hacker & Co., Inc. explains optical method for testing surface of materials, including metals, plastics, glass, and others. Describes accurate and convenient method for the examination and assessment of surface finish.

William J. Hacker & Co., Inc., 82 Beaver St., New York 8, N. Y.

Two-Million Volt X-Ray Generator—A two-million volt X-ray generator for the precise radiographic examination of a wide range of heavy castings, forgings, and weldments is available from the High Voltage Engineering Corp. The Van de Graaff Model AR supervoltage X-ray equipment has great penetrating power for routine radiography of steel sections up to 10 in. with short exposure times required of less than one minute for the thicknesses under 5 in. of steel. *Bulletin AR* available from the company.

High Voltage Engineering Corp., 7 University Rd., Cambridge 38, Mass.

Stir-O-Vac—*Bulletin No. 1280A* available from Labline, Inc., describes the new Stir-O-Vac for stirring under vacuum without mercury seal, now supplied with a high-speed ¼-hp series motor for operation up to 20,000 rpm.

Labline, Inc., 217–221 N. Des Plaines St., Chicago 6, Ill.

Controlled Volume Pumps in Process Instrumentation—*Bulletin 1253*, recently published by Milton Roy Co., describes and illustrates how Controlled Volume Pumps can be used as flow controllers, ratio controllers, and final control elements in process instrumentation. Copies available from the company.

Milton Roy Co., 1300 E. Mermaid Lane, Philadelphia 18, Pa.

Instrumentation—The current issue of *Instrumentation* published by the Industrial Div. of the Minneapolis-Honeywell Regulator Co. reports two articles dealing with industrial developments: one covers the manufacture of gamma globulin and describes how electronic instruments are harnessed to monitor extremely exacting processing operations; the other describes a sensitive weighing device, known as a recording analytical scale. Additional topics describe broad use of instruments.

Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne and Windrim Aves., Philadelphia 44, Pa.

Redesigned Low-Cost Ovens—Improved models of economical laboratory ovens and incubators, the Precision-Thelco line, are described in *Catalog No. 331A*, recently published by the Precision Scientific Co. Free copy of this catalog mailed on request.

Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

Recording Equipment—A recent issue of *Right Angle* published by the Industrial Div. of Sanborn Co. features two articles, one titled "More About Bridge Circuits" and the other covering "The Use of a Direct Writing Oscillograph in Connection with Steel Plant Electrical Drives."

Sanborn Co., Industrial Div., Cambridge 39, Mass.

LABORATORY NEWS

Lehigh Testing Laboratories, Wilmington, Del.—The organization of this laboratory has been announced by C. K. Mitchell, Director of Laboratories. The Laboratory will engage in research and development of foundry practice, metals processing, and paints and protective coatings; will conduct investigations of corrosion and oxidation of metals, lubrication problems, and metallurgical failures; and will serve as analysts of ferrous and non-ferrous metals, paints and rust preventatives, and petroleum and synthetic oils. The mailing address is P.O. Box 1241, Wilmington, Del.

Foster D. Snell, Inc., New York, N. Y.—Appointment of Ralph W. Kumler to the staff as a pulp and paper consultant has been announced by John B. Calkin, Assistant to the President.

John P. Baird Jones will be the technical representative for Foster D. Snell, Inc. in British Columbia, Canada, with offices at 627 Vancouver Block, Vancouver, B. C.

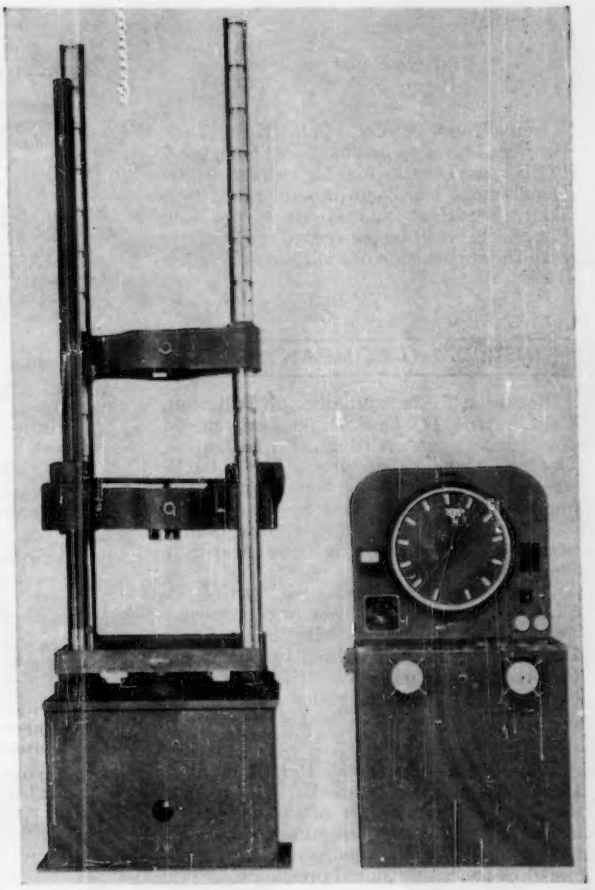
The latest issue of *The Chemical Digest* is available from this organization of consulting chemists and engineers. Lists of papers recently published and types of analysis undertaken by the Snell organization are included in this issue.

(*Continued on page 80*)

TESTING UNLIMITED

at costs you can afford!

Which of these quantities should you measure to do a better job of quality control?



Tension, Compression, Traverse, Fatigue—	Young Universal Testing Machines cover a range of 1,000 lbs to 5,000,000 mechanically or hydraulically driven complete with all accessories.
Thrust Load—	Young Thrust-Load Weighing Systems are available in pneumatic, hydraulic, or electrical models.
Strain—	Young Type A Strain Indicators include many unique design features. Also available are static and hi-speed switching units for up to 200 gages per sec. Young Bond Checkers check your strain gage application in 10 seconds.
Oscillographic—	Young Oscillographs cover from 6 to 60 channels; Amplifiers from 4 to 8 channels. Hi-speed cathode ray recorders, up to 8 traces, have paper speeds up to 150″ per sec. on 6″ wide paper. Developing and drying equipment for paper and film up to 18″ wide is available in combination and automatic units.
Special Measuring Instruments—	Others in the Young line include Huggenberger instruments; XY recorders up to 48 channels; hi-speed motion picture cameras. Special testing machines for cable, torsion, etc., manufactured to your specifications.

Here is the finest in testing priced to meet your budget. Based on years of specialized design and production of test equipment, Young offers you a versatility and knowledge that can solve your testing problems at minimum cost. If a standard machine is not the most economical answer, you'll find our engineers glad to design a machine that is. A letterhead request brings details. . . . write today.

Young Testing Machine Co.

750 Lancaster Ave. • P.O. Box 233-A
Bridgeport, Penna.

(*Continued from page 78*)

Sam Tour & Co., Inc., New York, N. Y.—The appointment of George J. Fischer as Director of the Metallurgical Department has been announced by Sam Tour, President and General Manager. Mr. Fischer will be concerned particularly with the supervision of metallurgical activities.

INSTRUMENT COMPANY NEWS

Beckman Instruments, Fullerton, Calif.—Arnold O. Beckman has announced the appointment of John F. Bishop as General Manager, Beckman Div., Beckman Instruments, Inc. He joined the company four years ago as head of the Beckman Special Products Group, and served the past two years as Assistant General Manager.

Appointment of Leonard J. Ortino as Chief Mechanical Engineer of the Special Products Dept. of the Beckman Div., Beckman Instruments, Inc., has been announced by the company. His efforts will be directed toward the development of new electromechanical systems.

Minneapolis-Honeywell Regulator Co., Philadelphia, Pa.—John H. Hagen has been appointed director of industrial relations for the Brown Instruments Div. of the company. He was formerly special assistant to the divisional president.

Calendar of Other Societies' Events

"Long" and "short" calendars will appear in alternate BULLETINS. The "short" calendar notes meetings in the few immediate weeks ahead—the "long" calendar for months ahead.

AMERICAN CONCRETE INSTITUTE—October 28–29, 7th Regional Meeting, Statler Hotel, Los Angeles, Calif.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS—October 28–29, Coal Conference, Pittsburgh, Pa.

AMERICAN WELDING SOCIETY—October 31–November 5, Hotel Sherman, Chicago, Ill.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS—November 1–3, Institute of Metals Div. Meeting, Hotel Sheraton, Chicago, Ill.

AMERICAN SOCIETY FOR METALS—November 1–5, National Metal Congress & Exposition, International Amphitheatre, Chicago, Ill.

TWELFTH ANNUAL PITTSBURGH DIFFRACTION CONFERENCE—November 3–5, Joint Meeting with the American Crystallographic Assn., Mellon Institute, Pittsburgh, Pa.

AMERICAN COUNCIL OF COMMERCIAL LABORATORIES—November 3–6, Annual Meeting, Roosevelt Hotel, New Orleans, La.

STRUCTURAL CLAY PRODUCTS INSTITUTE—November 6–10, Annual Convention, Hotel del Coronado, San Diego, Calif.

MINERALOGICAL SOCIETY OF AMERICA—November 8–10, Annual Meeting, Los Angeles, Calif.

NATIONAL ACADEMY OF SCIENCES—November 8–10, Autumn Meeting, Columbia University, New York, N. Y.

AMERICAN PETROLEUM INSTITUTE—November 8–11, Annual Meeting, Conrad Hilton Hotel and Palmer House, Chicago, Ill.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS—November 10–13, 62nd Annual Meeting, Waldorf-Astoria Hotel, New York, N. Y.

OPERATIONS RESEARCH SOCIETY OF AMERICA—NOVEMBER 19–20, Fall Meeting, Sheraton-Park Hotel, Washington, D. C.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS—November 28–December 1, 50th Annual Meeting, Ben Franklin Hotel Philadelphia, Pa.

MANUFACTURING CHEMISTS ASSN.—November 23, Statler Hotel, New York, N. Y.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—November 28–December 3, Annual Meeting, Statler Hotel, New York, N. Y.

AMERICAN ROCKET SOCIETY—December 1–3, Annual Meeting, Statler Hotel, New York, N. Y.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS—December 1–4, Electric Furnace Steel Conf., Hotel William Penn, Pittsburgh, Pa.

21ST NATIONAL EXPOSITION OF POWER AND MECHANICAL ENGINEERING (ASME auspices)—December 2–7, Commercial Museum, Philadelphia, Pa.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS—December 6–8, Winter Meeting, Edgewater Beach, Chicago, Ill.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS—December 12–15, Annual Meeting, Statler Hotel, New York, N. Y.

INSTITUTE OF THE AERONAUTICAL SCIENCES—December 17, Washington, D. C.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE—December 26–31, National Meeting, University of California, Berkeley, Calif.

COLOUR PROBLEMS?

you can solve them
efficiently
accurately
definitively

if you measure colour with colour with

LOVIBOND

TINTOMETERS & COMPARATORS

- All use the world-renowned Lovibond colour scale — the oldest, most definitive name in colour measurement.
- Internationally distributed Lovibond colour standards are made in one factory only ensuring absolute colour uniformity at all times.
- Hundreds of permanent glass colour standards and discs available or we can create any standard to your specifications. Available also for Wesson and other colorimeters.
- Write for list of publications on Colorimetry and FREE brochure *T-11*

Manufactured exclusively by **THE TINTOMETER, LTD.**
"The Greenwich observatory of Colour Measurement"
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The bath is made of corrosion-resistant stainless steel, spot-welded and soldered to assure leakproof construction. A drain-overflow holds the level of the bath liquid at the prescribed height on the Saybolt tubes. The bath can be drained conveniently through external connections.

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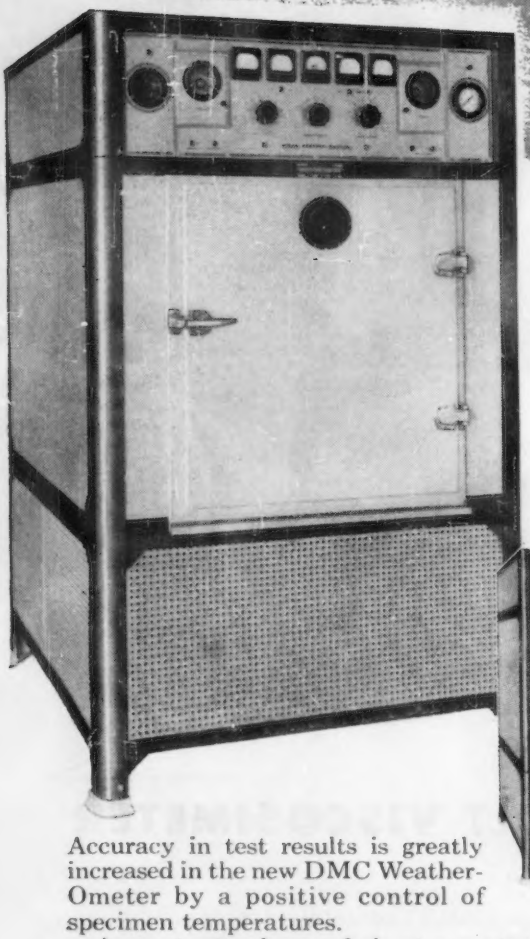
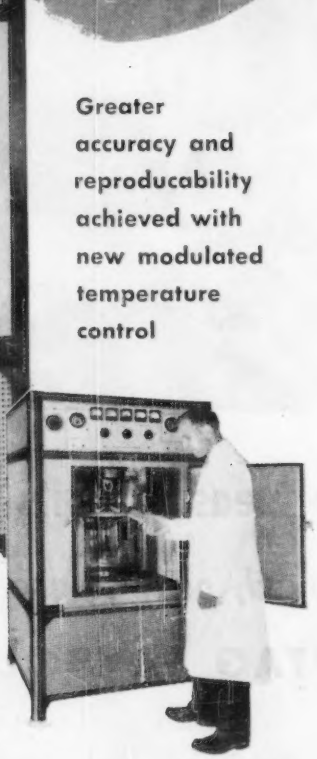
A NEW Weather-Ometer® BY ATLAS...

MODEL DMC



Greater accuracy and reproducability achieved with new modulated temperature control



Accuracy in test results is greatly increased in the new DMC Weather-Ometer by a positive control of specimen temperatures.

A constant volume of air at a controlled temperature in the heavily insulated cabinet, maintains uniform predetermined specimen temperatures regardless of variations in room conditions.

Automatic control of humidities up to dew point is available as optional equipment.

All automatic controls including complete voltage controls are located on the front panel of the Weather-Ometer directly above the door of the test chamber.

Both horizontal and vertical testing is available. Shallow containers are used for semi-liquid materials and vertical panels for solid materials.

Source of radiation is two Atlas enclosed violet carbon arcs.

Complete technical information on the DMC model and other Weather-Ometers is contained in the new Weather-Ometer catalog. A copy will be mailed on request.

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WEATHER-OMETERS • FADE-OMETERS • LAUNDER-OMETERS

Inert Atmosphere Chamber Developed at NBS

A VERSATILE inert atmosphere chamber with an associated purifying system has been constructed at the National Bureau of Standards, where it is proving useful in the Bureau's research in electrodeposition. The chamber permits all the common manipulations such as filtration, distillation, transfer, and weighing to be carried out without contamination of reactants or products with oxygen, water vapor, or carbon dioxide.

As a result of the current widespread interest in a variety of atmosphere-sensitive chemicals, such as hydrides, borohydrides, and metal-organic compounds, there has been a growing need for a device that will permit the chemical manipulation of these materials without resort to elaborate and time-consuming sealed systems often applicable to only one operation. Experience with the NBS inert atmosphere chamber over the past two years indicates that it should meet the requirements of most groups that are working with atmosphere-sensitive chemicals on a laboratory scale.

The apparatus consists of two principal parts: the air-free chamber, or "dry box," and the purification train. The whole is a closed system, that is, the inert gas passes continuously from the box through the purifying system and back to the box. An antechamber, with an extension for use with longer pieces of apparatus, permits the introduction of apparatus without contamination of the inert atmosphere within the box. Manipulations are performed through four aluminum ports to which are cemented shoulder-length rubber gloves.

A pump, enclosed in a gas-tight cylinder, circulates the inert gas in sequence through an apparatus for the removal of oxygen (in parallel with a by-pass), a heat exchanger to remove heat of compression, two activated alumina dryers in parallel for removal of water vapor, the dry box and its antechamber, and a trap for the removal of acidic gases which might harm the pump or other parts of the system. The gas then returns to the pump to complete the cycle. The acid trap, containing coarsely granular soda lime, also eliminates carbon dioxide from the atmosphere of the box. Oxygen is removed from the system by passing the gas over copper at 550 C in a specially designed apparatus. Continuous regeneration of the copper is achieved by periodically adding hydrogen to the atmosphere of the dry box.

(*Continued on page 83*)

(*Continued from page 82*)

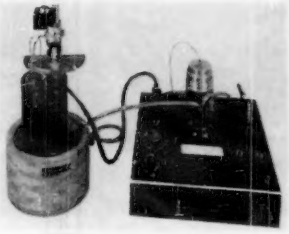
When apparatus is to be put into the box, the outer door of the antechamber is opened, and the apparatus, supported in a specially constructed wire basket, is placed in the antechamber. The outer door is then closed, and the antechamber is evacuated. The inert gas is let into the antechamber until atmospheric pressure is obtained, after which the inner door can be opened and the apparatus can be transferred to the box, working through the gloves. Volatile materials to be taken into the box are kept in a bomb if the evacuation method is used. Otherwise the antechamber is flushed by passing a quantity of the inert gas through it from a supply cylinder. After a suitable period this gas flow can be stopped, and a portion of the flow from the purification train can be directed through the antechamber, effecting a final clean-up before the inner door of the antechamber is opened.

Within a period of eight hours or less, the system can be filled with inert gas, and the enclosed atmosphere can be virtually freed of oxygen and water vapor. Spilled droplets of liquid sodium-potassium eutectic retain a bright surface after several hours exposure to this atmosphere. While a quantitative estimation of the water vapor in the box has not been made, the oxygen content has been found to be less than 0.1 per cent and the indications are that it is much lower. The extreme dryness of the box is indicated by the fact that no fumes can be seen when a bottle of titanium tetrachloride is opened inside the box.

Stainless Steel Spectrographic Standards

THE National Bureau of Standards has announced the availability of three stainless steel spectrographic standard samples of the 18 Cr-8 Ni type. The standards are issued in the form of rods $\frac{7}{32}$ in. in diameter and 4 in. long. Concentrations are listed in the provisional certificate of analysis for nine minor and trace constituents within the following ranges: Al 0.0003–0.0025 per cent, B 0.0005–0.0033 per cent, Cu 0.11–0.24 per cent, Pb 0.002–0.004 per cent, Mo 0.12–0.22 per cent, Nb 0.03–0.21 per cent, W 0.08–0.18 per cent, V 0.032–0.12 per cent, and Zn 0.003–0.005 per cent. The samples, numbered 442, 443, and 444, may be purchased from the National Bureau of Standards, Washington 25, D. C., at a price of $8 each.

Rubber Testing
INSTRUMENTS
For ASTM and Other Tests

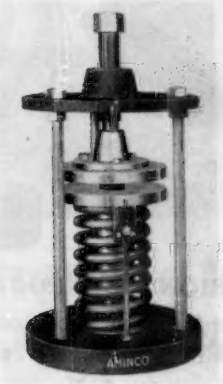


COLD-FLEX TESTER
For Rubber and the Like

For accurately measuring torsional stiffness, flexure, or permanent set of rubber and similar elastic materials at temperatures from plus 40° C. to minus 90° C. according to ASTM D 1053.

Torsional measurements accurate to 3%.

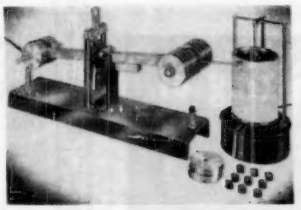
Absolute temperature determinable within plus-minus 1° C. Temperature of samples within the cold chamber are held uniform within plus-minus 1° C.



COMPRESSION SET APPARATUS

For determining compression set of vulcanized rubber according to ASTM D 395.

Two types: (1) The self-contained portable device (illustrated) for measuring compression set under constant load; (2) A device for measuring compression set under constant deflection.

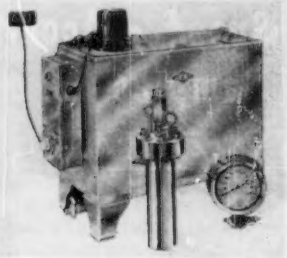


RUBBER OSCILLOGRAPH

Provides an autographic record in a few minutes from which can be evaluated certain mechanical properties of rubber and rubber-like materials as a basis for the evaluation of these properties as vibration absorbers, in accordance with ASTM D 945. Used also as a valuable auxiliary to a fatigue machine to evaluate a test piece throughout the duration of a life test.

Measures static and dynamic characteristics, also effective dynamic modulus.

Can be used in refrigerators and ovens for testing over a wide range of temperatures.



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A reliable means of determining the ageing properties of rubber according to ASTM D 572.

The bombs (either 1100 or 4640 ml. capacity) are equipped with improved safety features and tested to 2000 psi.

The baths (for 2 or 4 bombs) maintain test temperatures up to 100° C. (constancy within plus-minus 0.2° C.) by means of reliable and time-tested controls.

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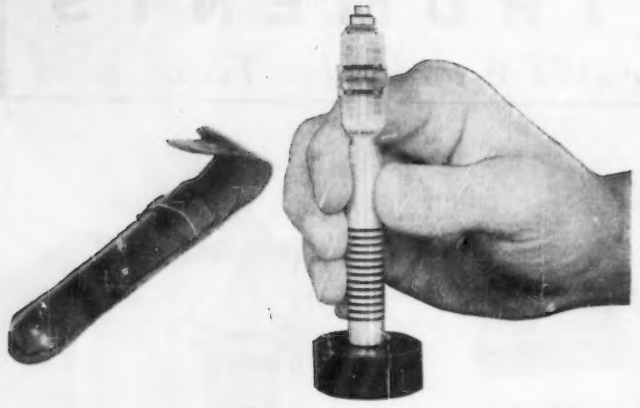

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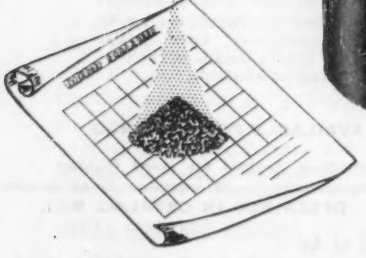

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New Supplement to SLA List of Translations

A SUPPLEMENTARY list of translations received in the Special Libraries Assn. Translation Pool became available from the John Crerar Library on Sept. 1, 1954. This supplement to the *SLA List of Translations, October, 1953*, lists nearly 700 titles received in the Pool since October, 1953. Orders can now be placed at $1 per copy with payment in advance to:

SLA Translation Pool
John Crerar Library
86 East Randolph St.
Chicago 1, Ill.

Under contract with the Special Libraries Assn., The John Crerar Library now maintains and services the Translation Pool. At the present time approximately 2000 translations from all languages except Russian are on file.

When available in paper copies, translations may be borrowed for a service charge of $1.50 for each translation, including postage. Crerar may determine whether translations will be available by loan or by photocopy. Photoprint or microfilm copies may be obtained at the regular rate charged by Crerar Library. Currently, these rates are $1.40 for ten pages or fraction thereof for photoprint, or fifty pages or fraction thereof for microfilm, *plus* a service charge of $1 for each translation, payable in advance. Discounts of 3½ to 14 per cent are allowed on advance purchase of photoduplication coupons.

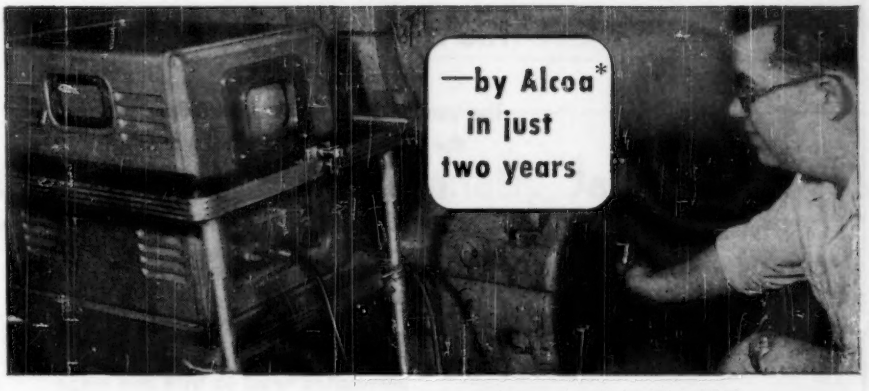
Wire and Cable Symposium

THE Third Annual Wire and Cable Symposium jointly sponsored by the Signal Corps Engineering Laboratories, Fort Monmouth, and by the Wire and Cable Industry will be held December 7 through 9, 1954, at the Berkeley Carteret Hotel, Asbury Park, N. J. The program will cover wire and cable materials, their characteristics and uses; wire and cable constructions, together with manufacturing and equipment problems; field construction methods; and uses in systems operation. For further details, write H. L. Kitts, Coles Signal Laboratory, Fort Monmouth, N. J.

R. C. Lanphier Appointed

ROBERT C. LANPHIER, JR., during the summer was appointed Deputy Assistant Secretary of Defense (Supply and Logistics). Formerly associated with Sangamo Weston Ltd., in Springfield, Ill., Mr. Lanphier has served as Director of Planning and Review in the Office of Assistant Secretary T. P. Pike.

$1,000,000 SAVED



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OUR NEW BULLETIN 50-105 tells the whole story . . . just *how, where* and *why* the Ultrasonic Testing Reflectoscope can cut your costs from raw materials to finished product. To get your copy immediately, fill out and mail the attached coupon today.

* "We have had over two years experience in nondestructive testing with the Sperry Ultrasonic Reflectoscope. It has been used for the regular inspection of all our extrusion presses. Some 19 press columns have been removed before failure on data provided by the Reflectoscopes. The resultant savings in press damage and down time are estimated to exceed well over $1,000,000."
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TYPICAL TEST PATTERNS on Reflectoscope screen. At left, material O.K. At right, center "reflection" indicates and locates defect.

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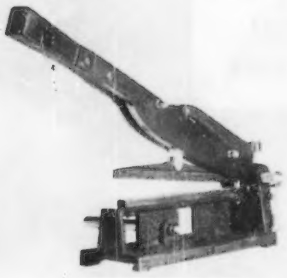

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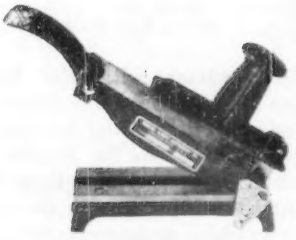

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